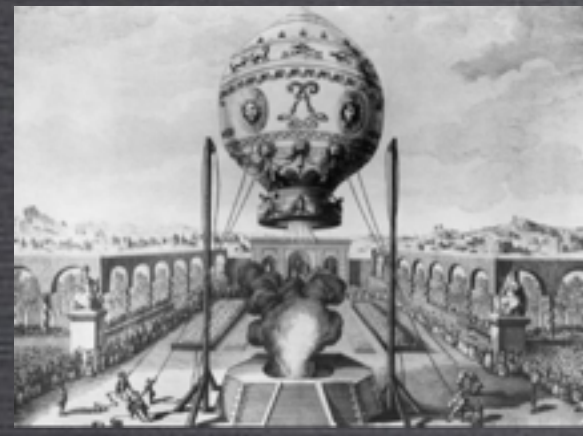


UNE HISTOIRE DES RAYONS COSMIQUES ET DE L'OBSERVATOIRE PIERRE AUGER

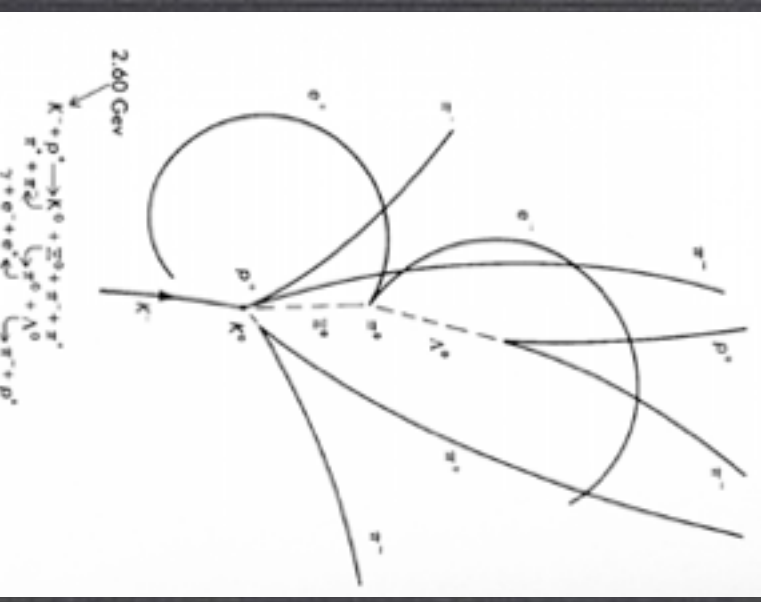


CHEMINEMENT

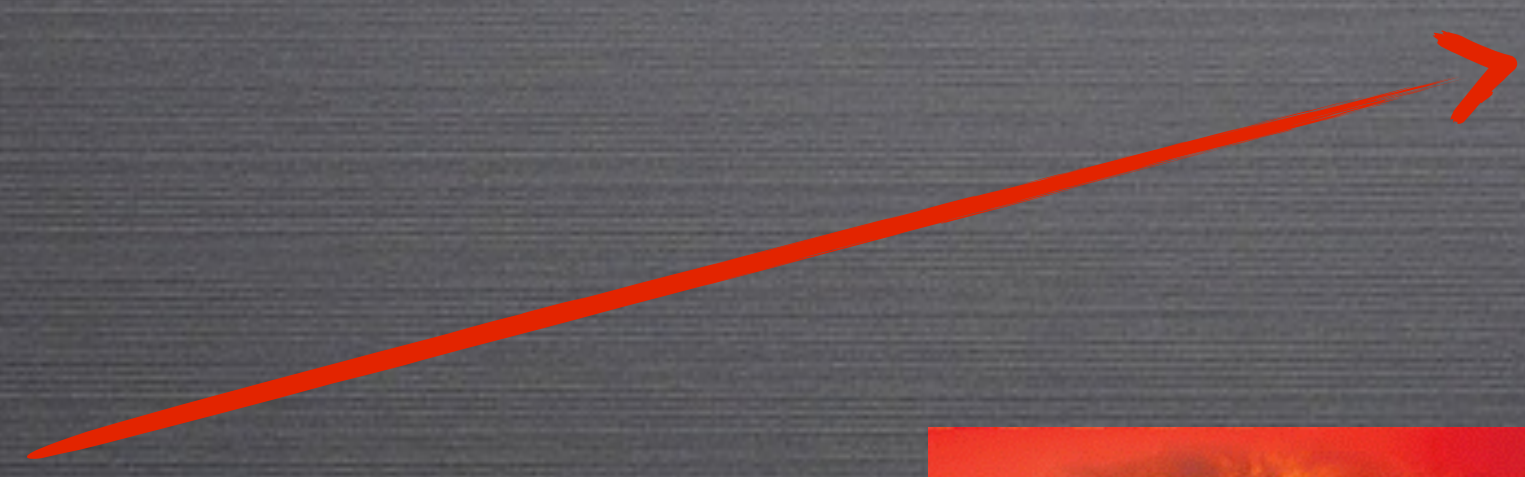
RADIATIONS



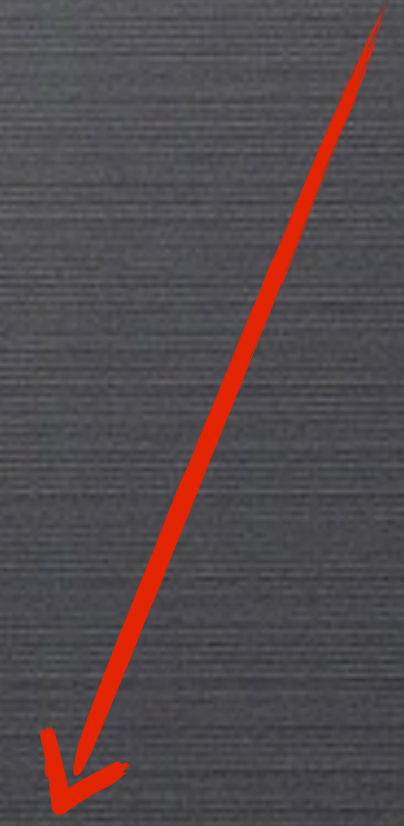
PREMIERS PAS



BESTIAIRE

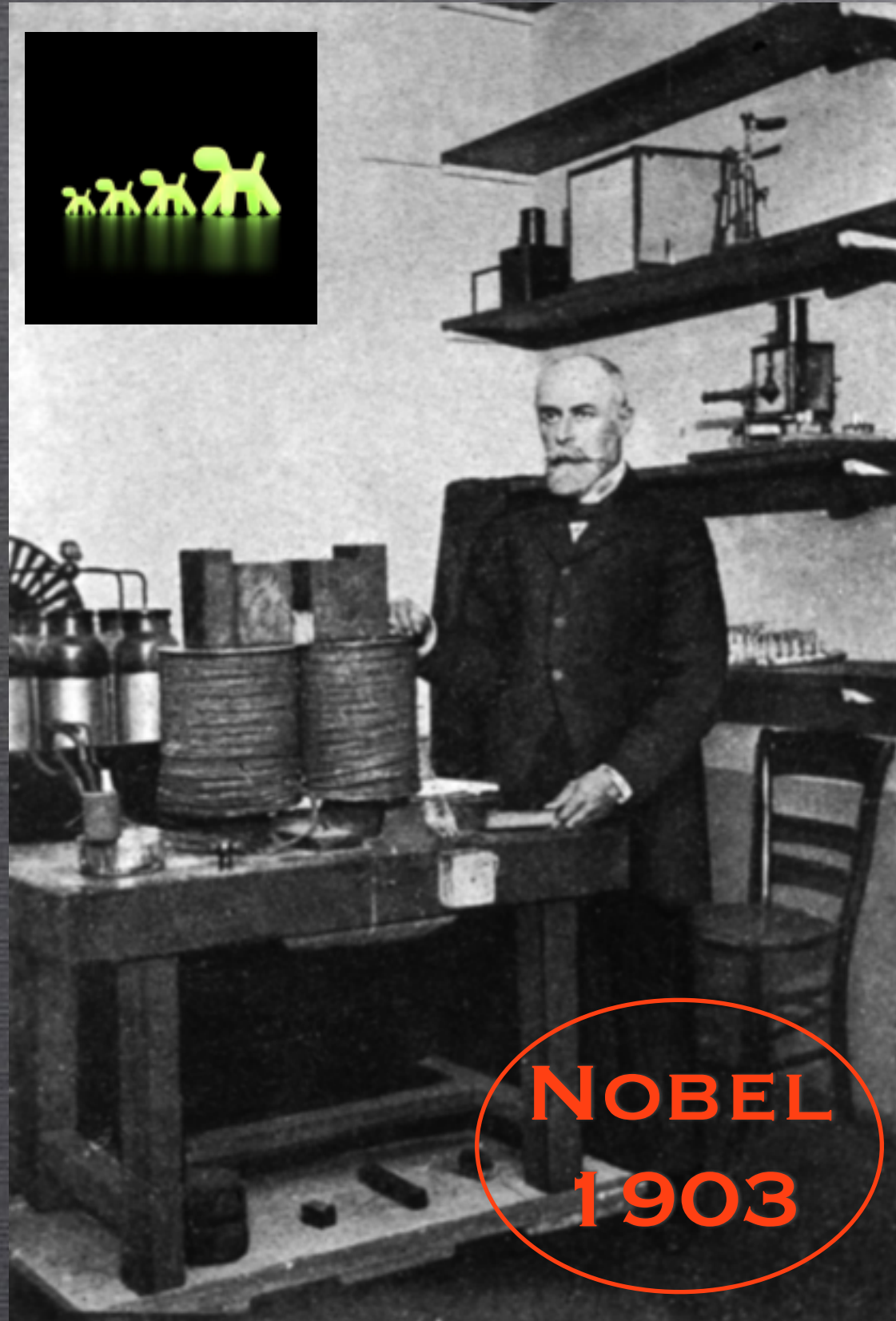


DE PLUS EN PLUS GRAND



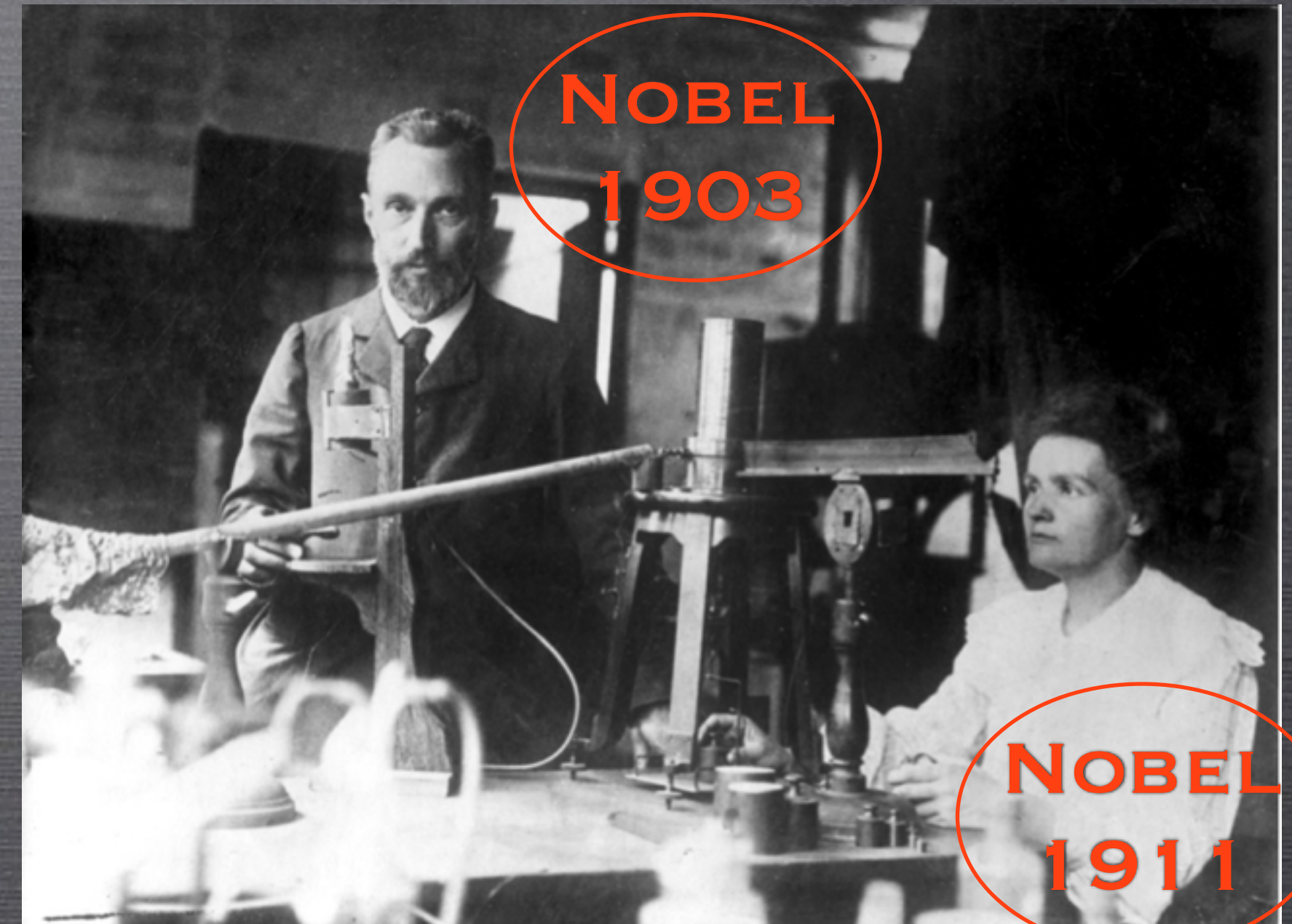
LES ÉNERGIES EXTRÊMES

RADIATIONS



**NOBEL
1903**

Antoine Henri Becquerel



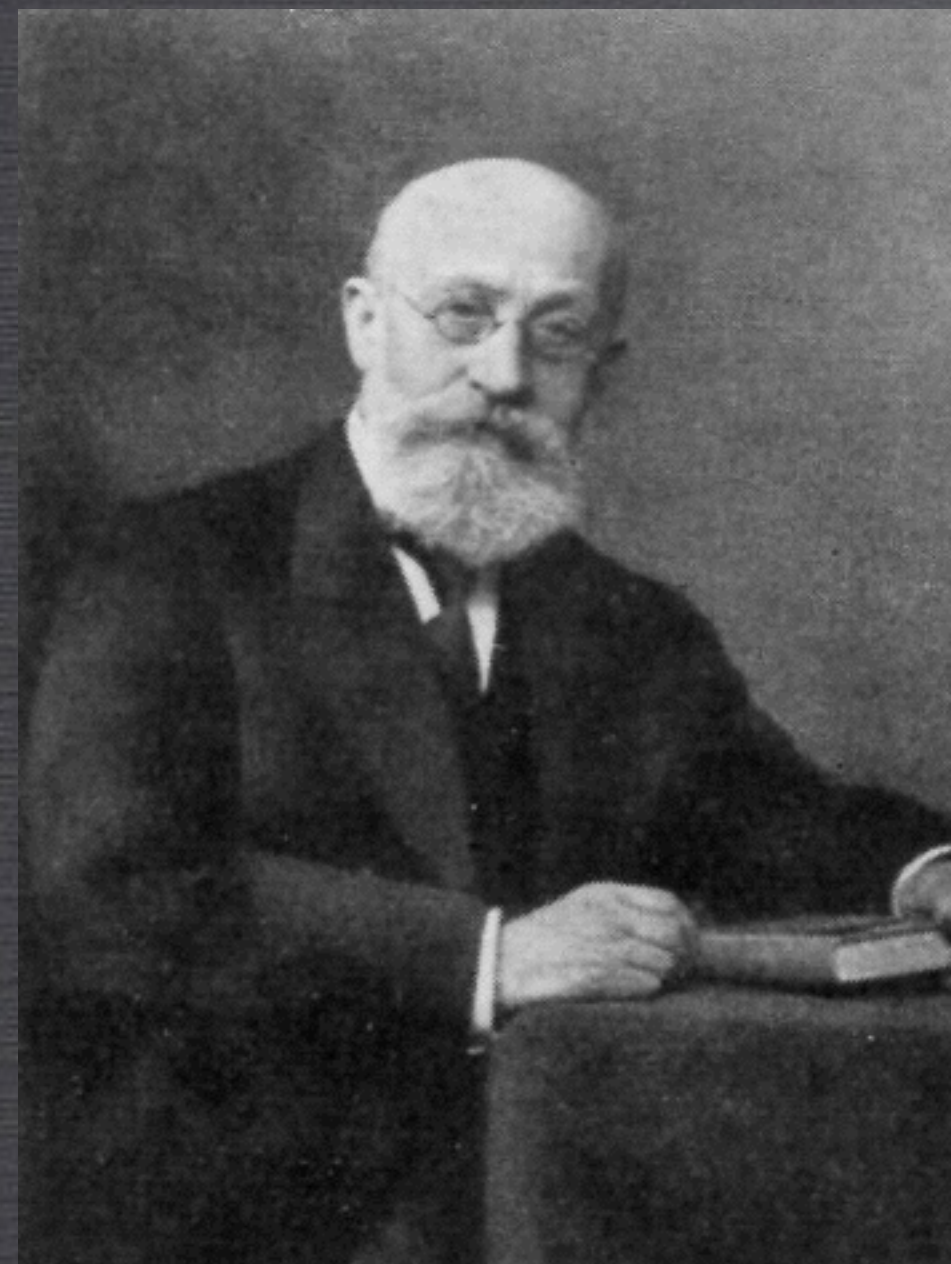
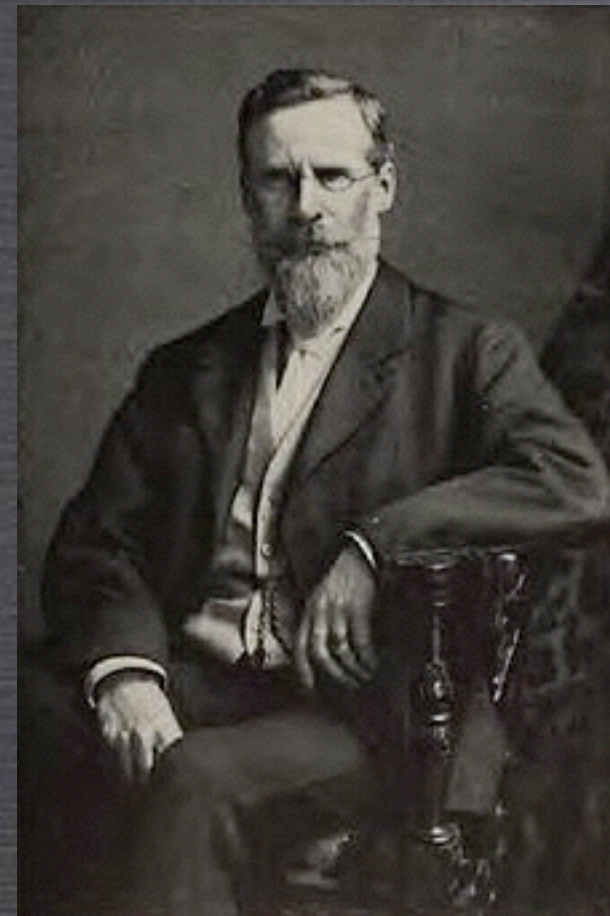
**NOBEL
1903**

**NOBEL
1911**

Pierre et Marie Curie

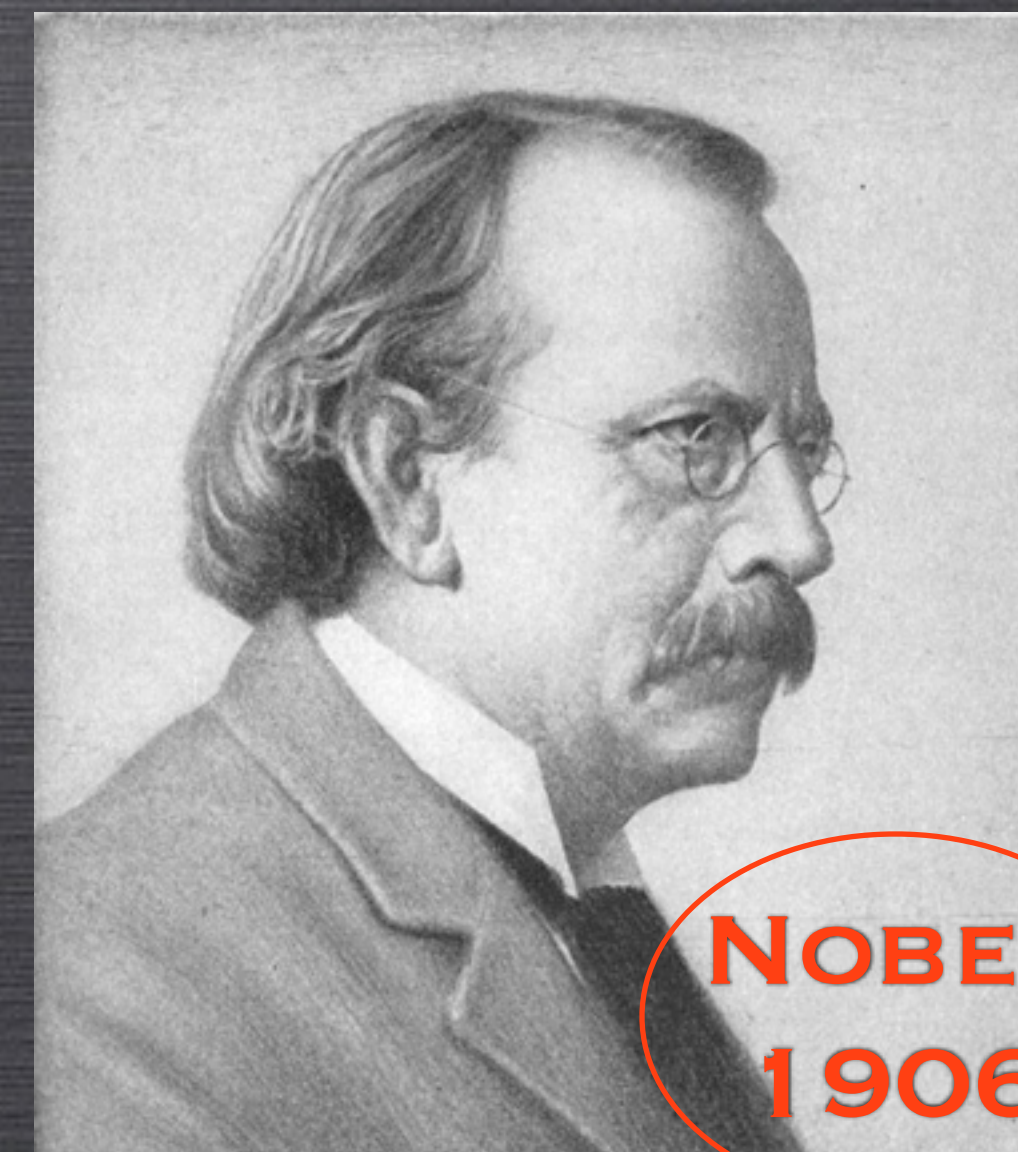
RAYONS CATHODIQUES (1870) & ÉLECTRONS (1897)

Sir William Crookes



Eugen Goldstein

J. Thomson.



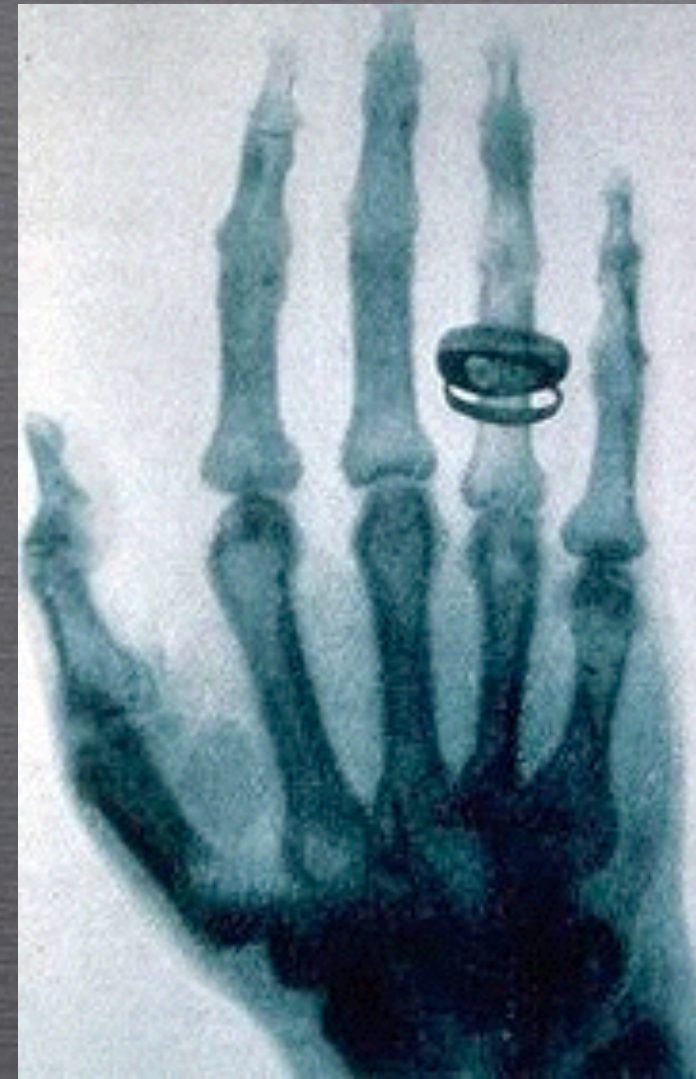
**NOBEL
1906**

RAYONS X (1895)



NOBEL
1901

W. RÖNTGEN



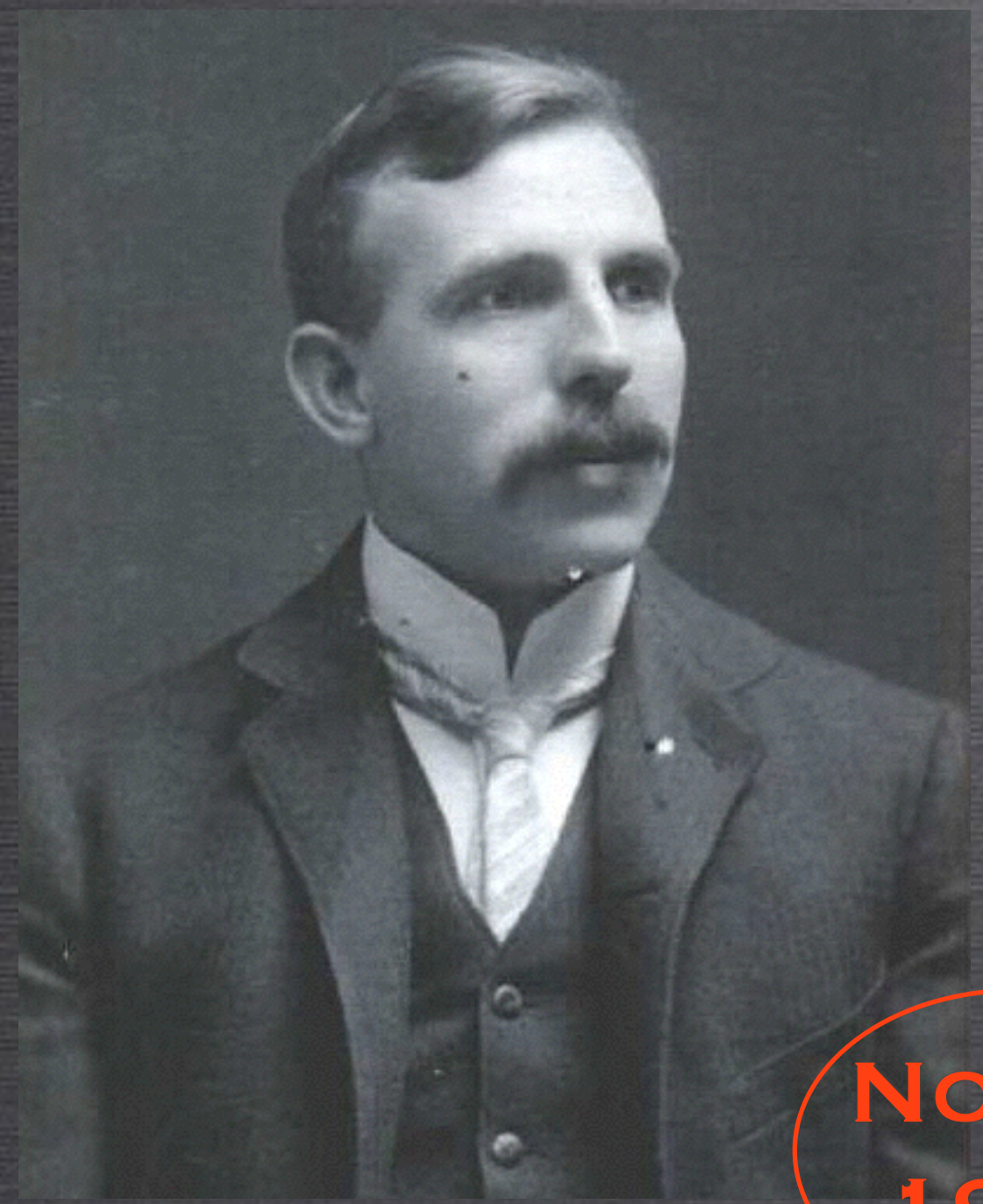
1896



1895

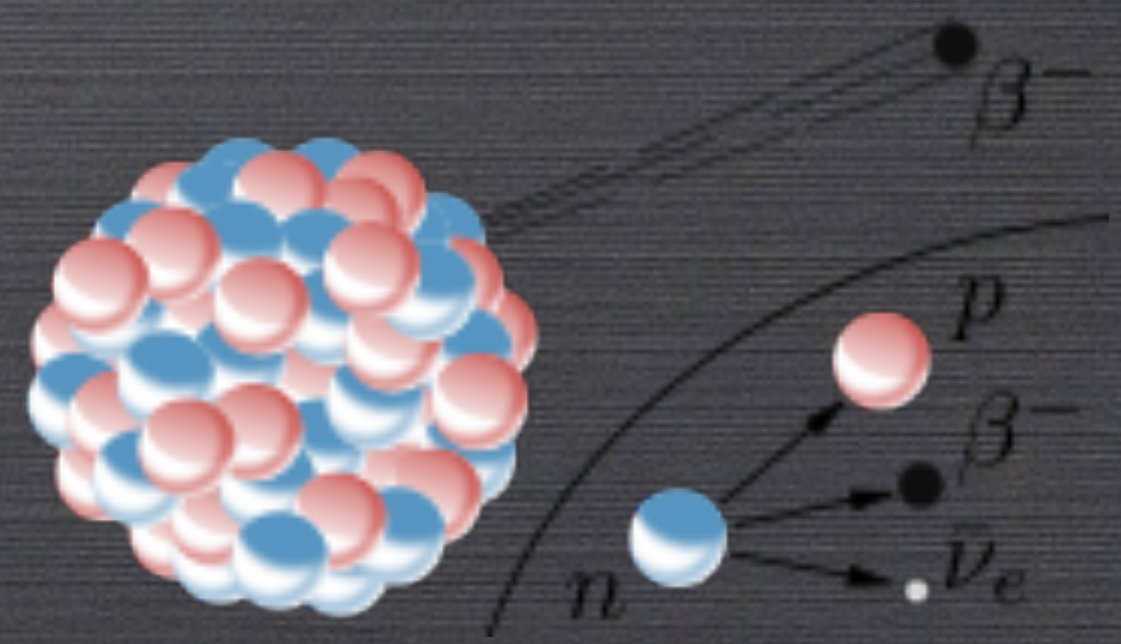
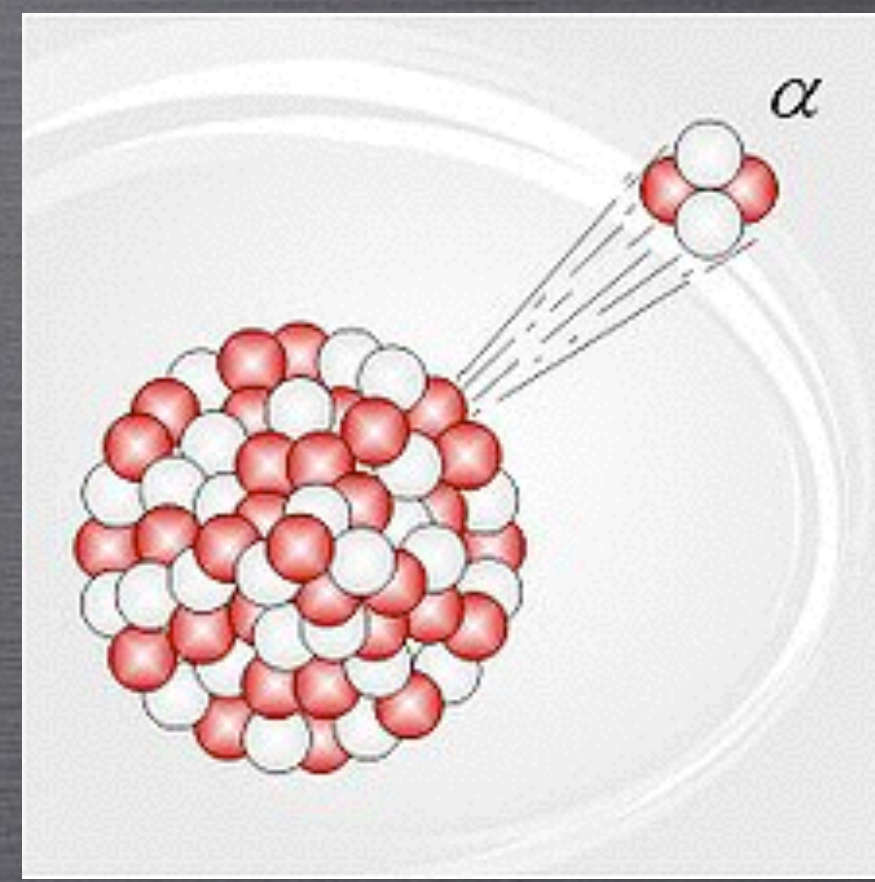


RAYONS ALPHA & BETA (1899)

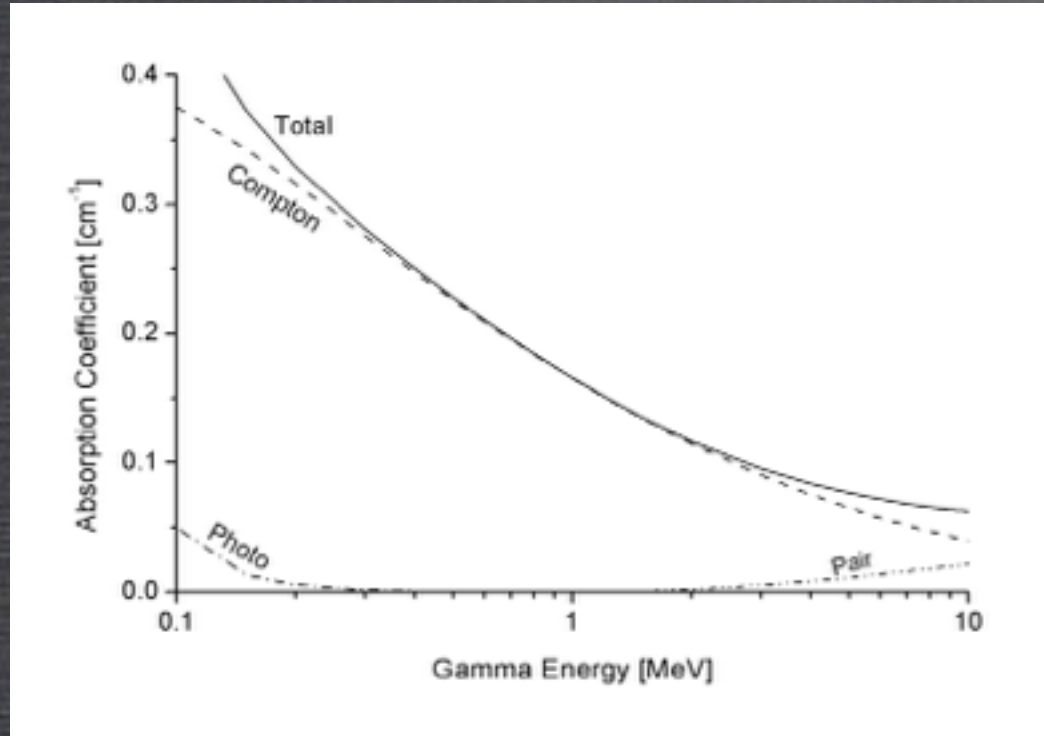
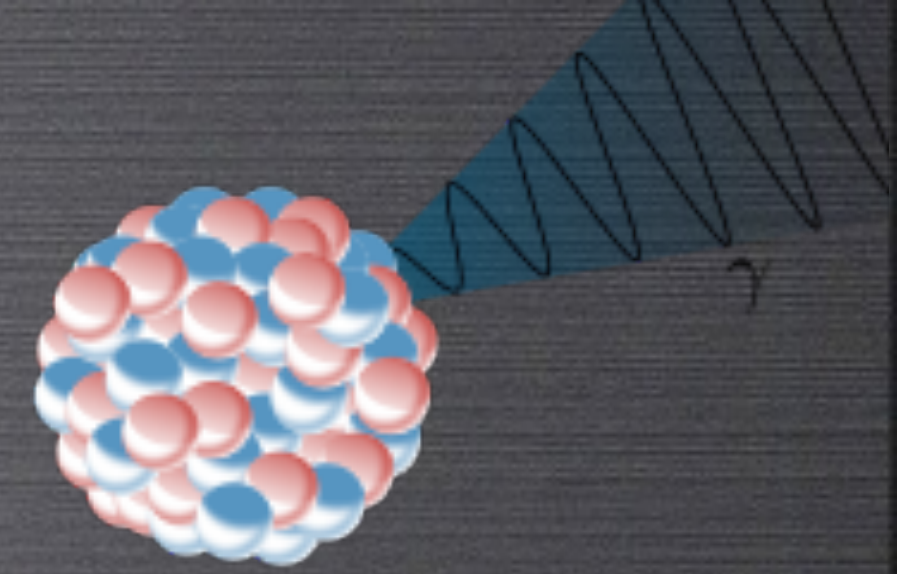


NOBEL
1908

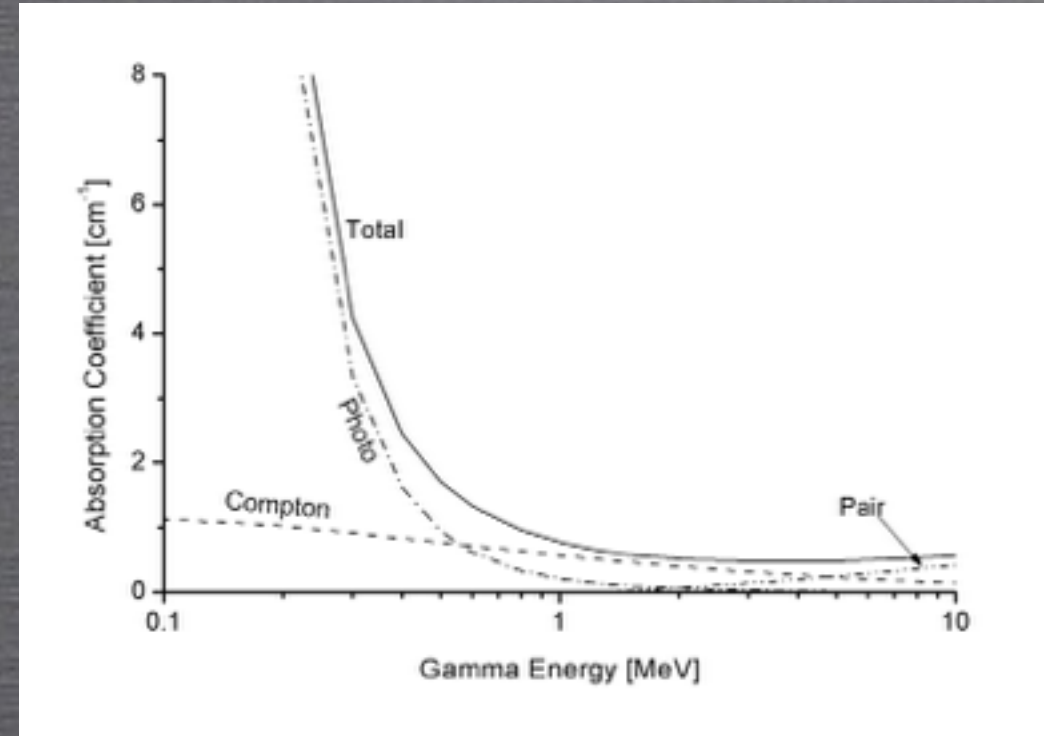
Rutherford



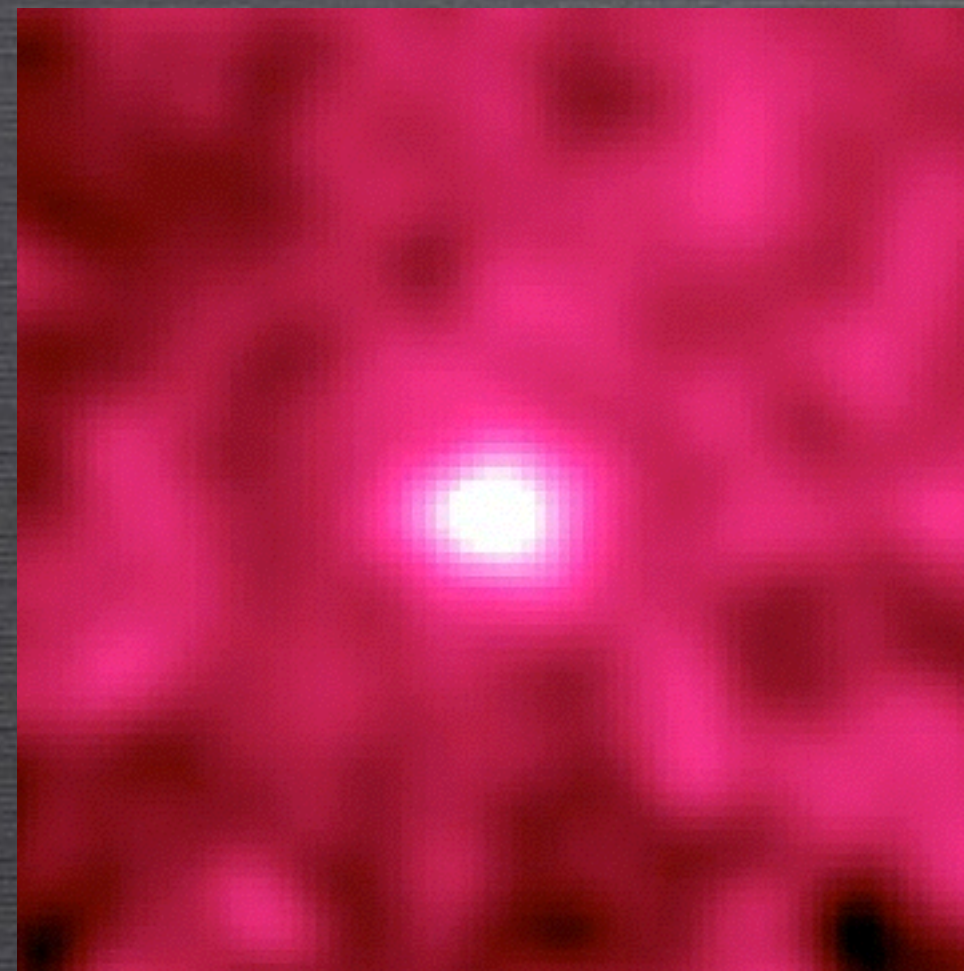
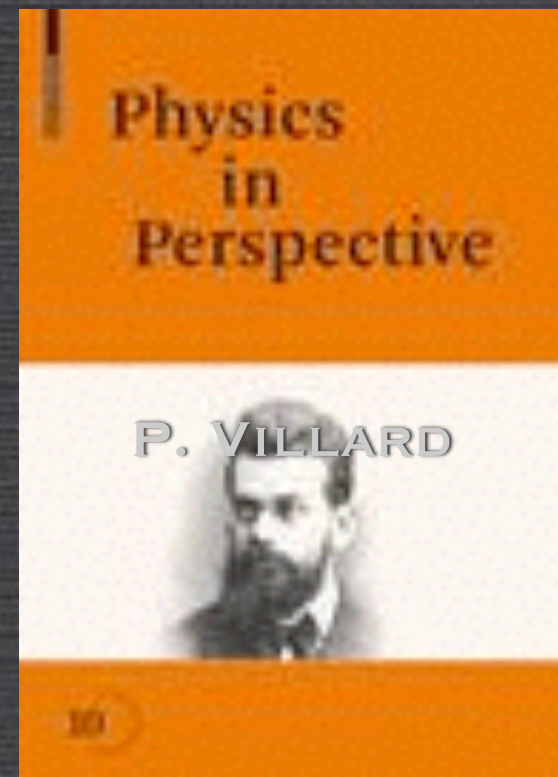
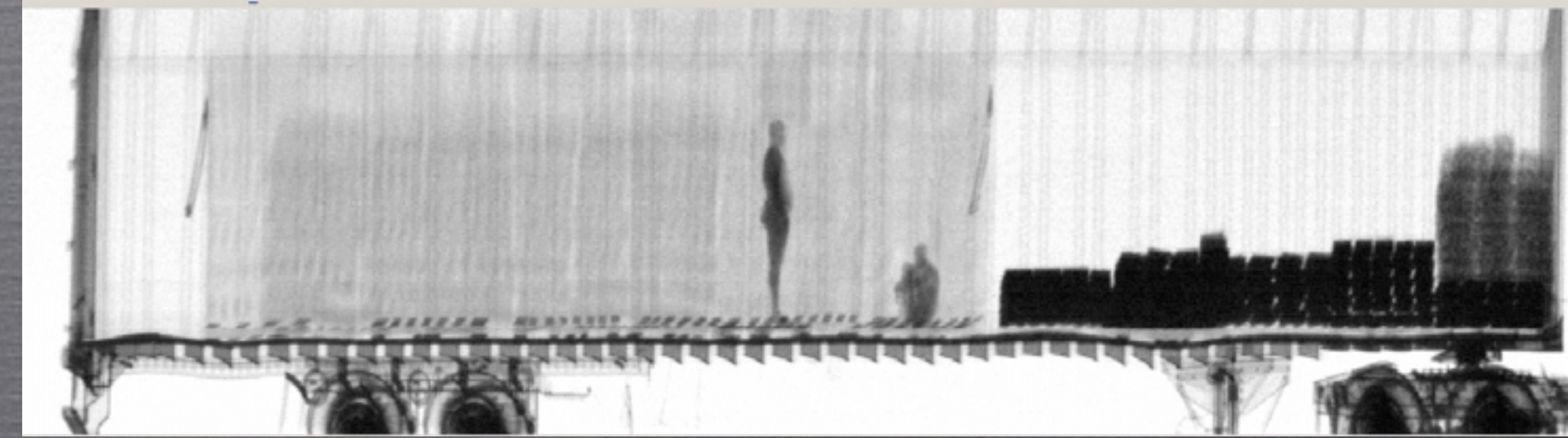
RAYONS GAMMA (1900)



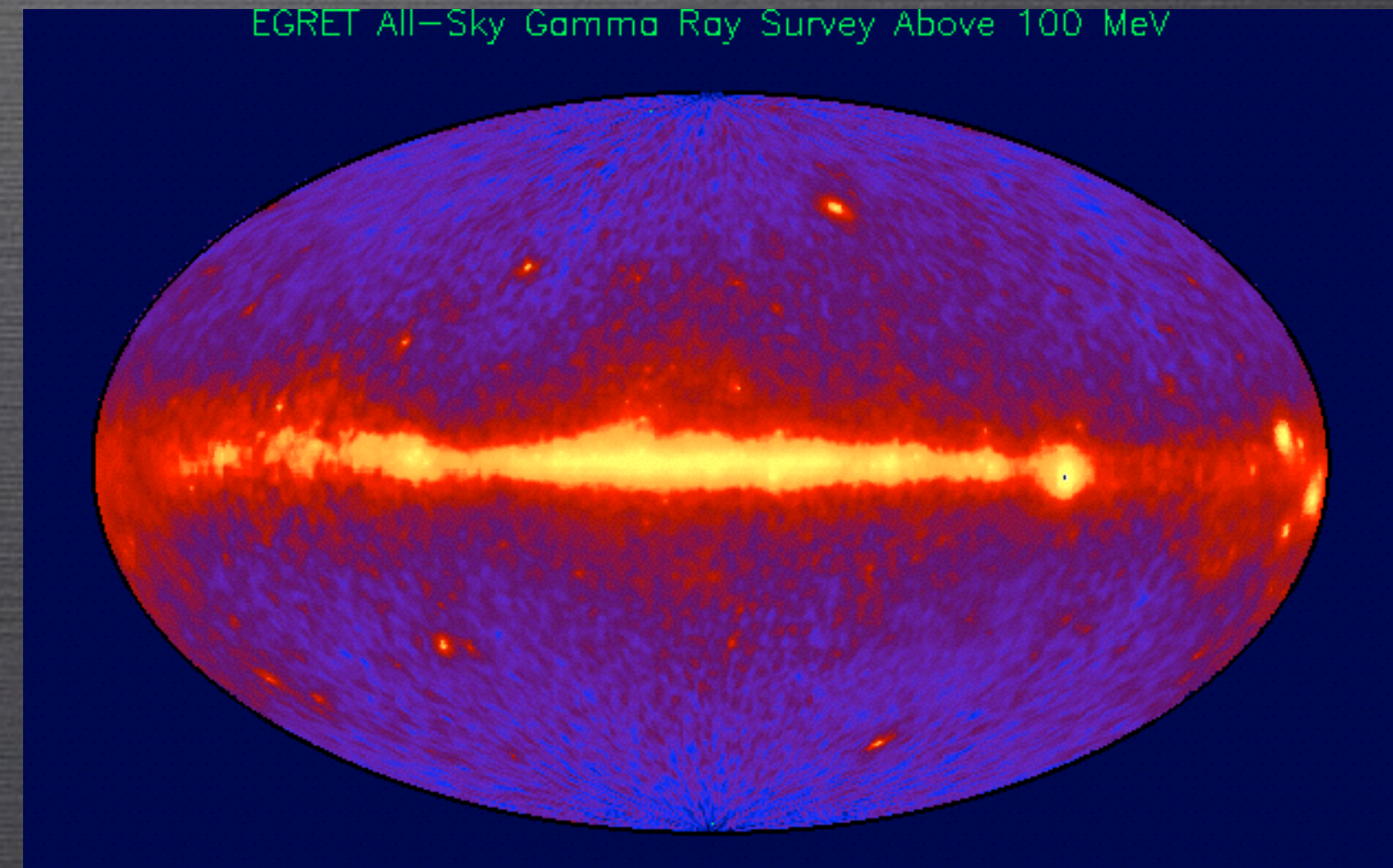
Aluminium



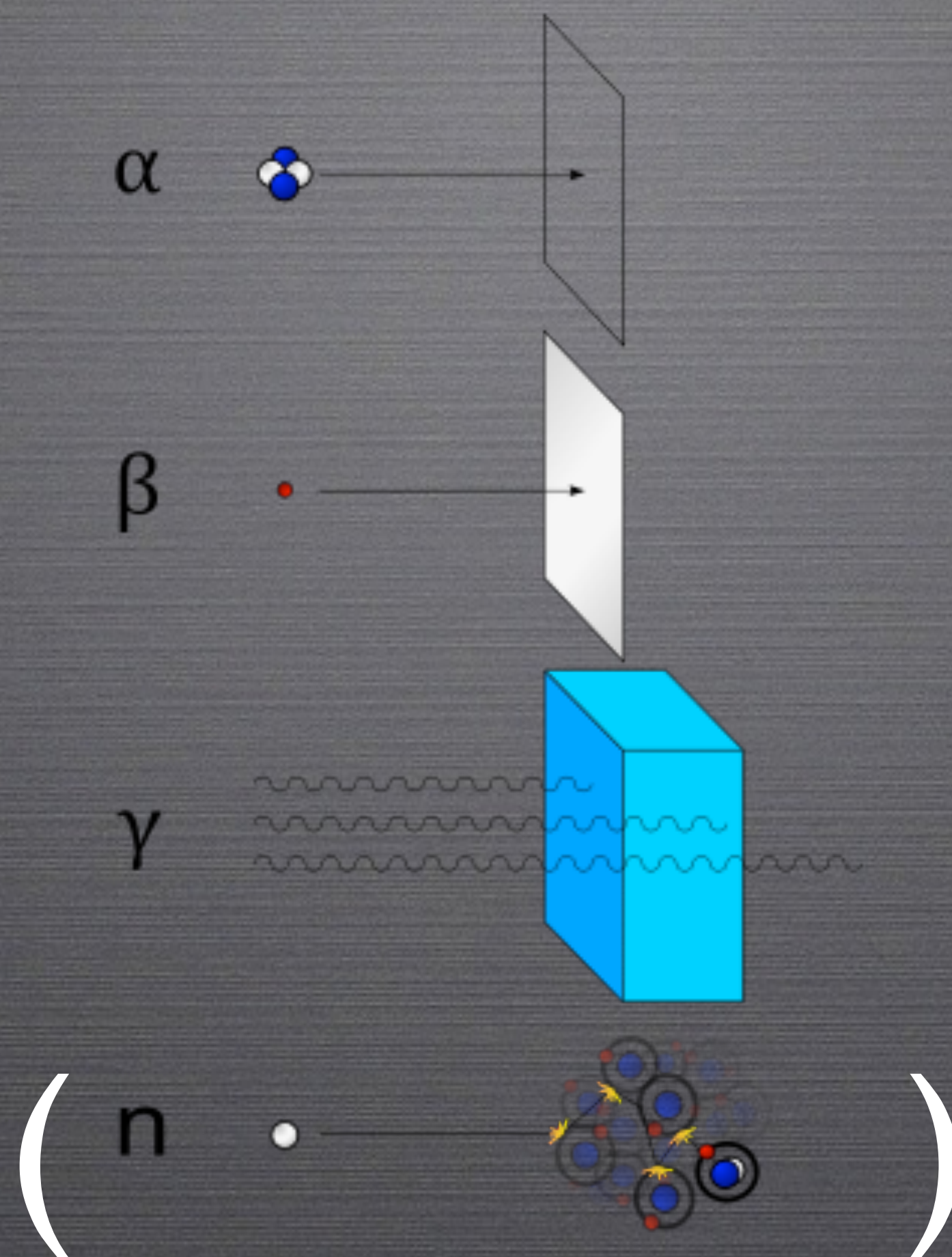
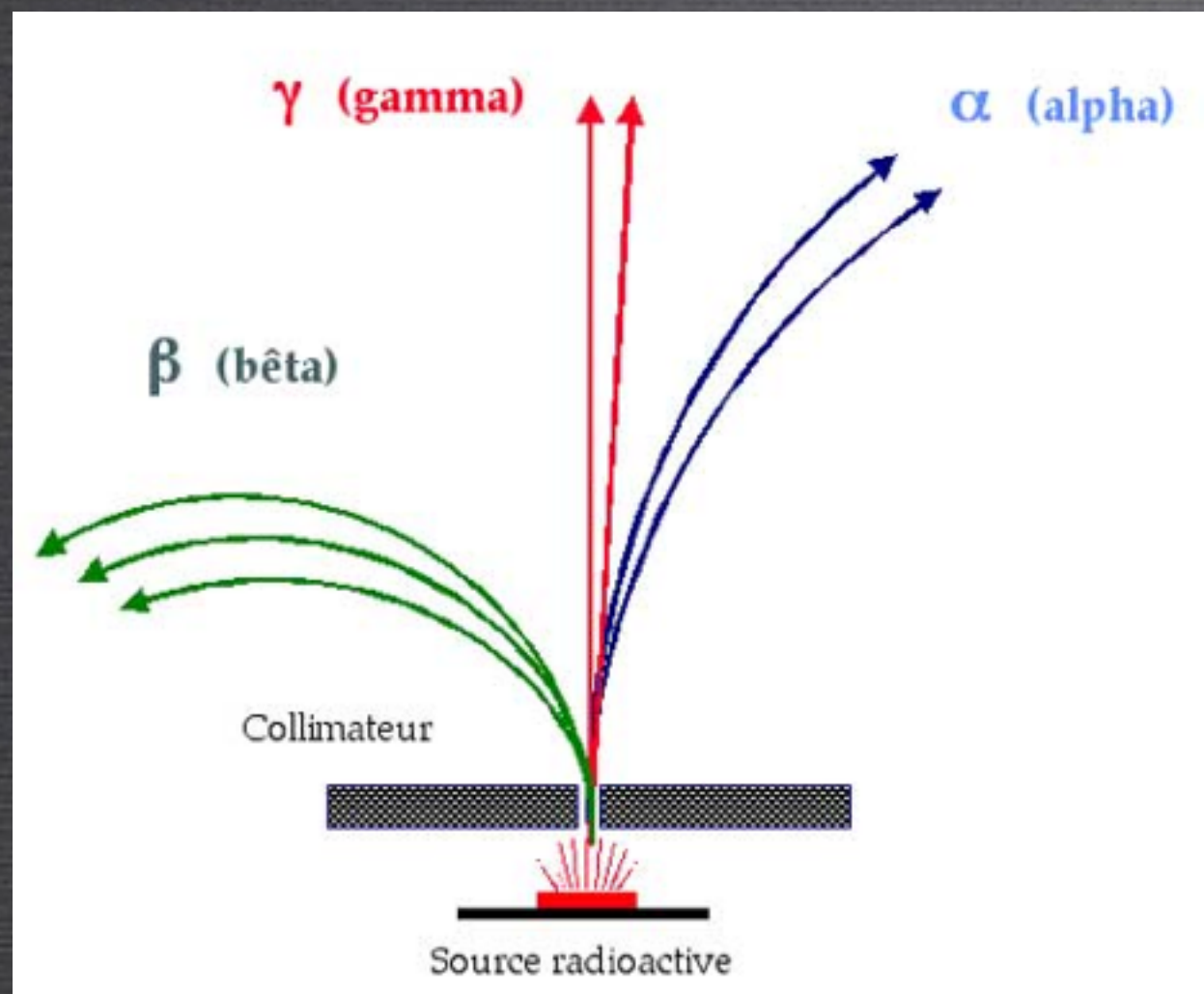
Plomb



La Lune

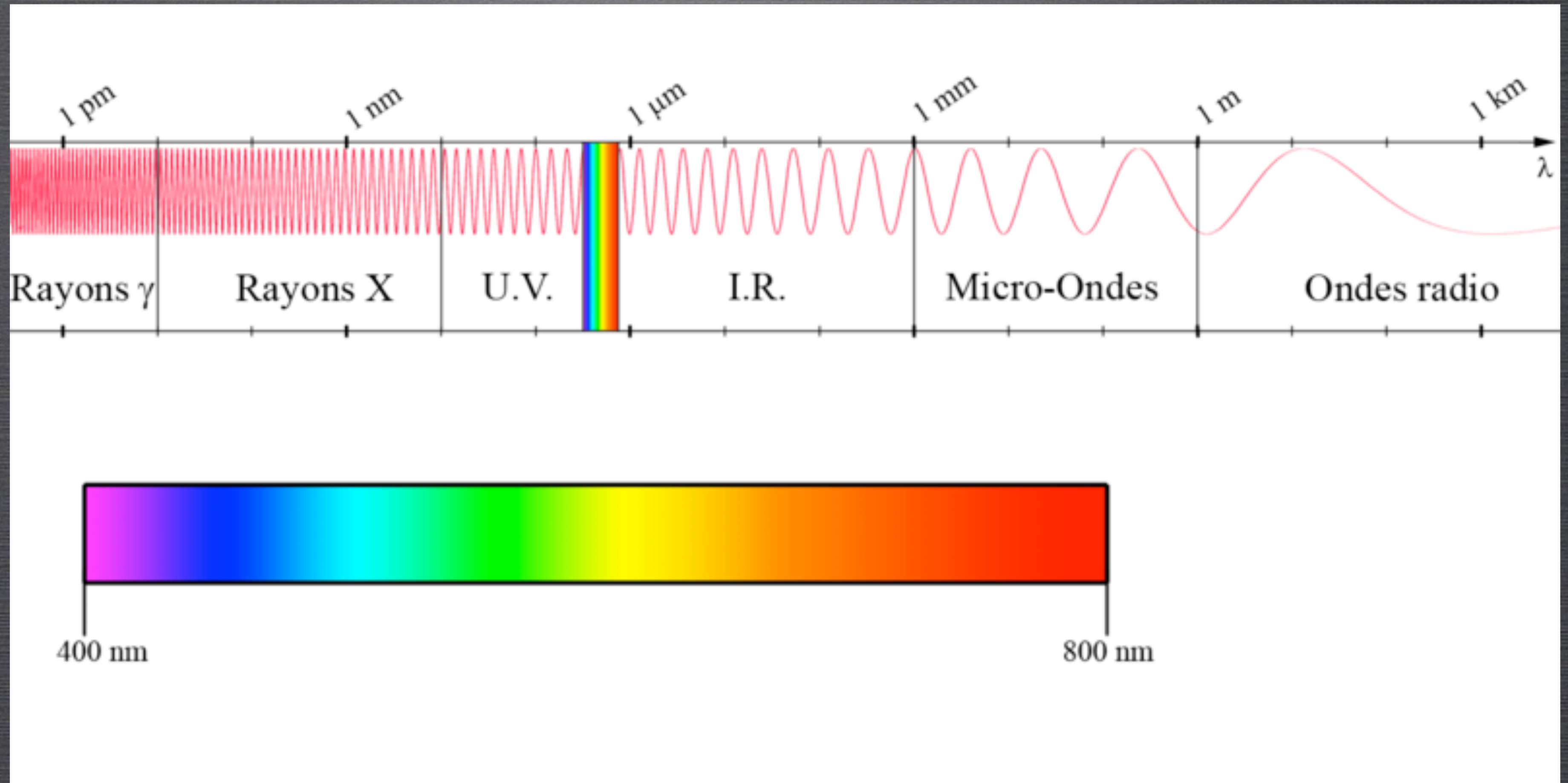


LES RAYONNEMENTS AU DÉBUT DU XXIÈME SIÈCLE



DIFFÉRENTS TYPES DE RADIATIONS
PLUS OU MOINS PÉNÉTRANTES

QUELQUE TEMPS PLUS TARD ...



β = électron, α = Hélium, γ = photons, X = photons + neutrino

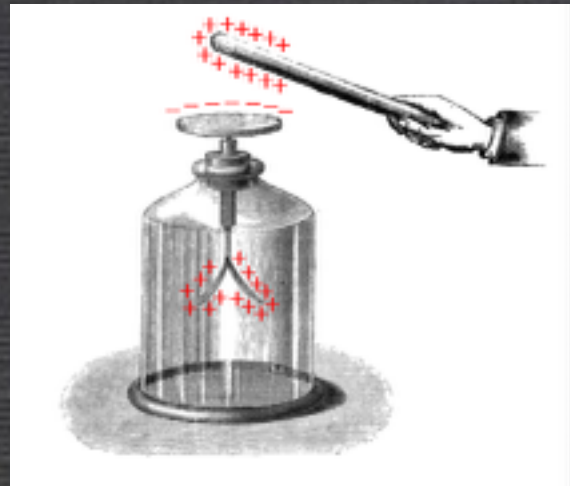
DÉCHARGE



Charles de Coulomb



Theodor Wulf



Victor Hess

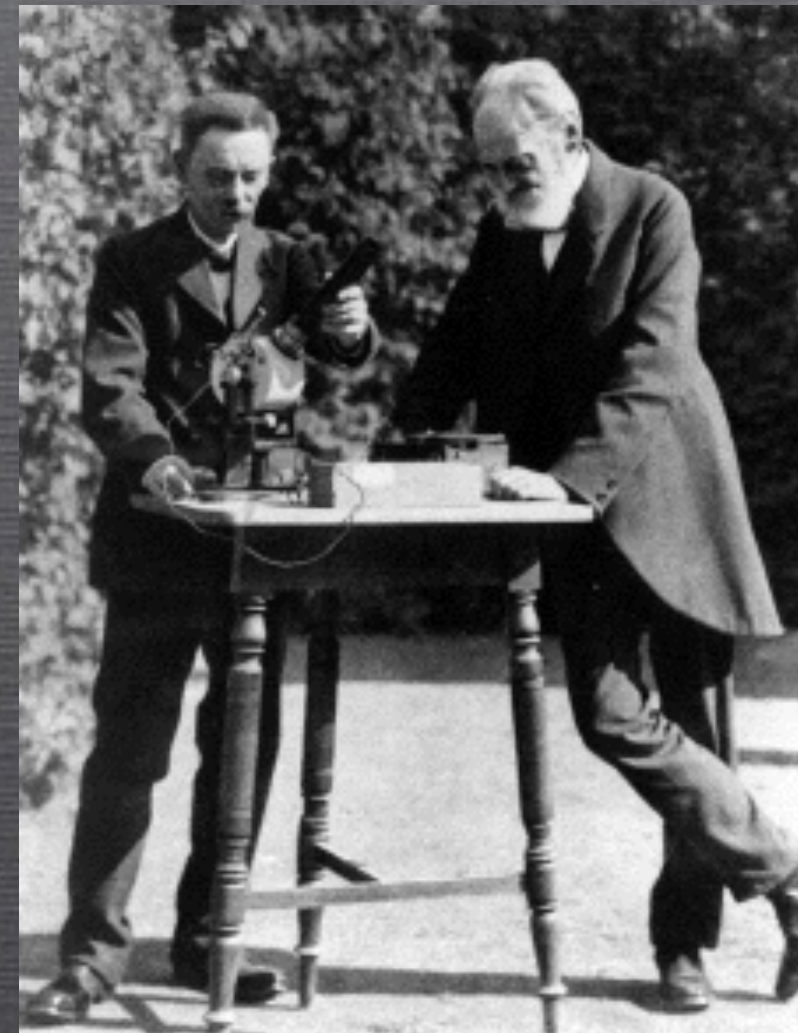
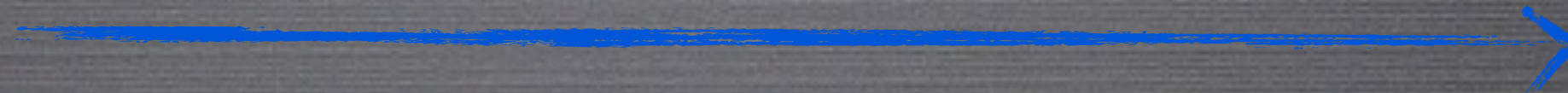


Robert Millikan

PREMIERS PAS



LA DÉCHARGE DES ÉLECTROSCOPES...

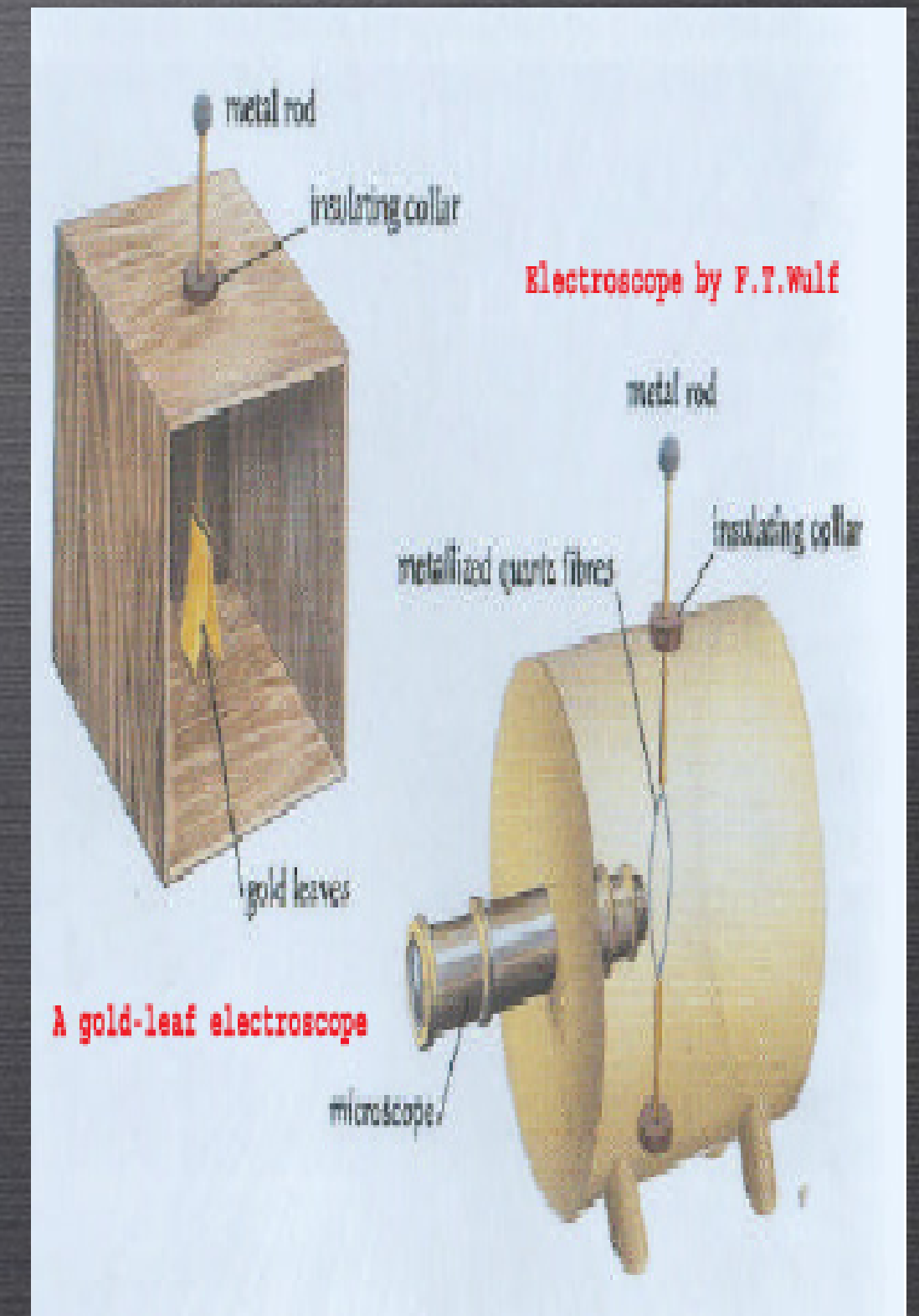
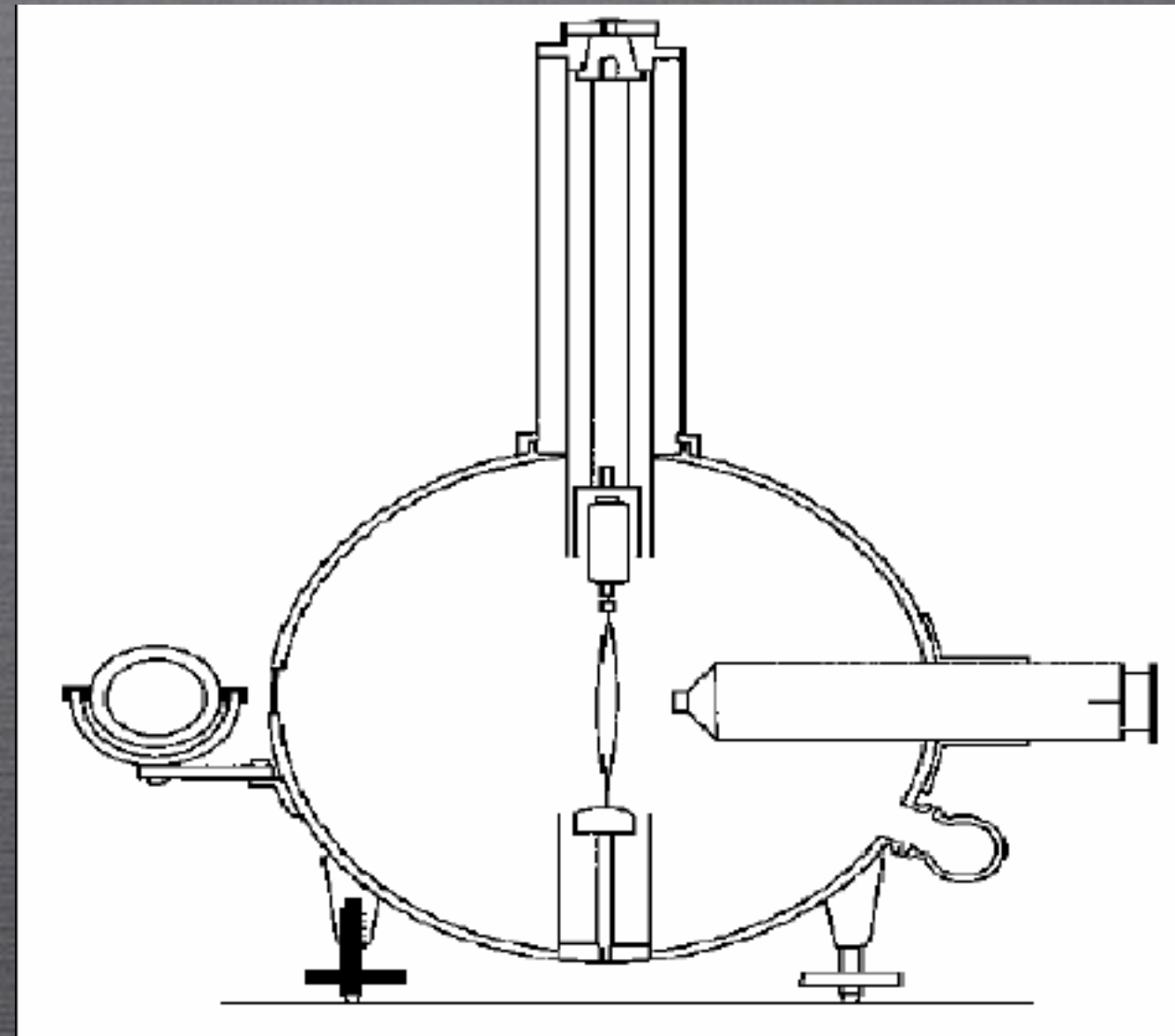


ELSTER & GEITEL

THÉODORE WULF (1907)



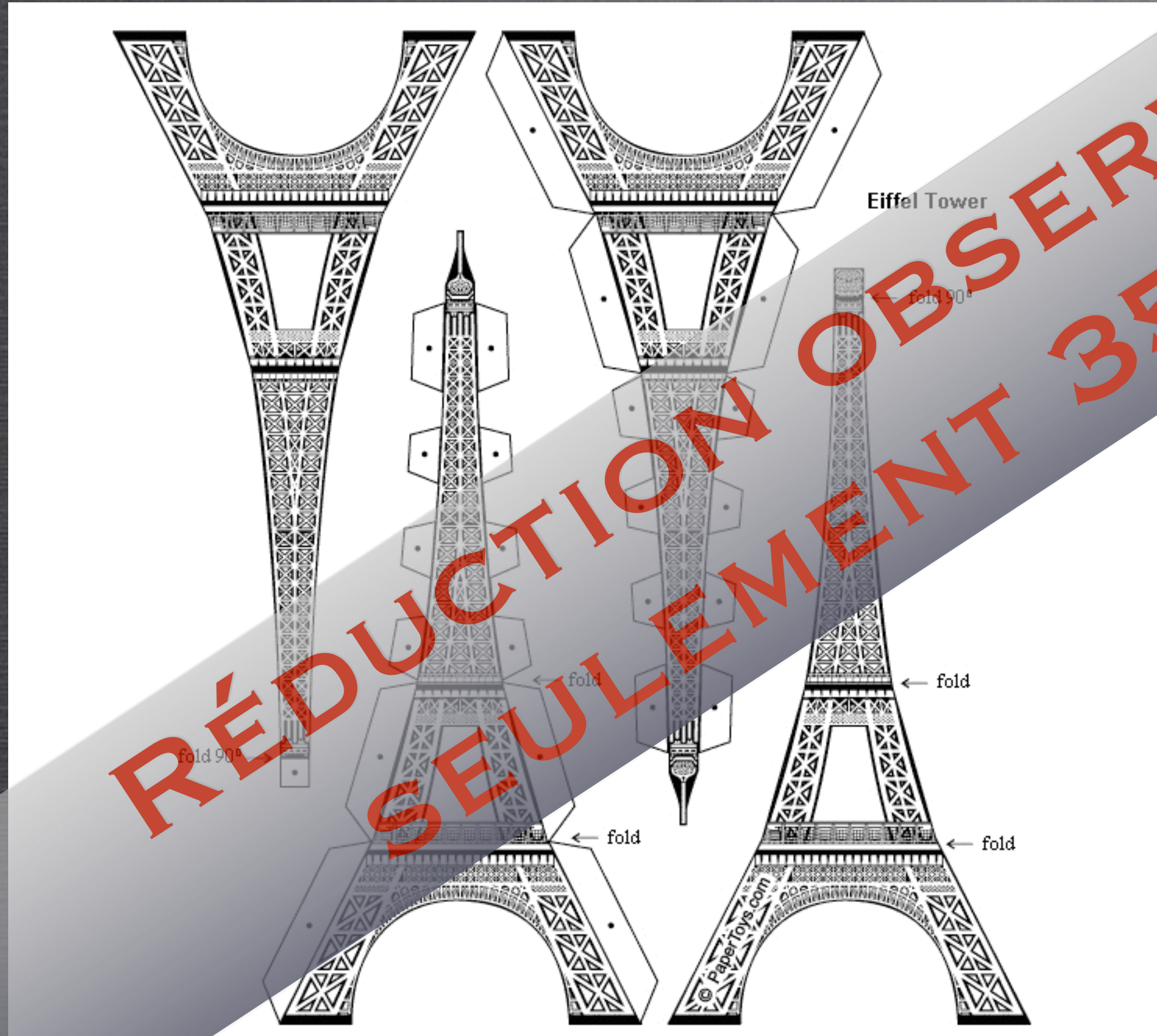
↑
330 M



RÉDUCTION ATTENDUE:

50% TOUS LES 80M SOIT PLUS DE 90% AU SOMMET

THÉODORE WULF (1907)



RÉDUCTION OBSERVÉE :
SEULEMENT 35%!

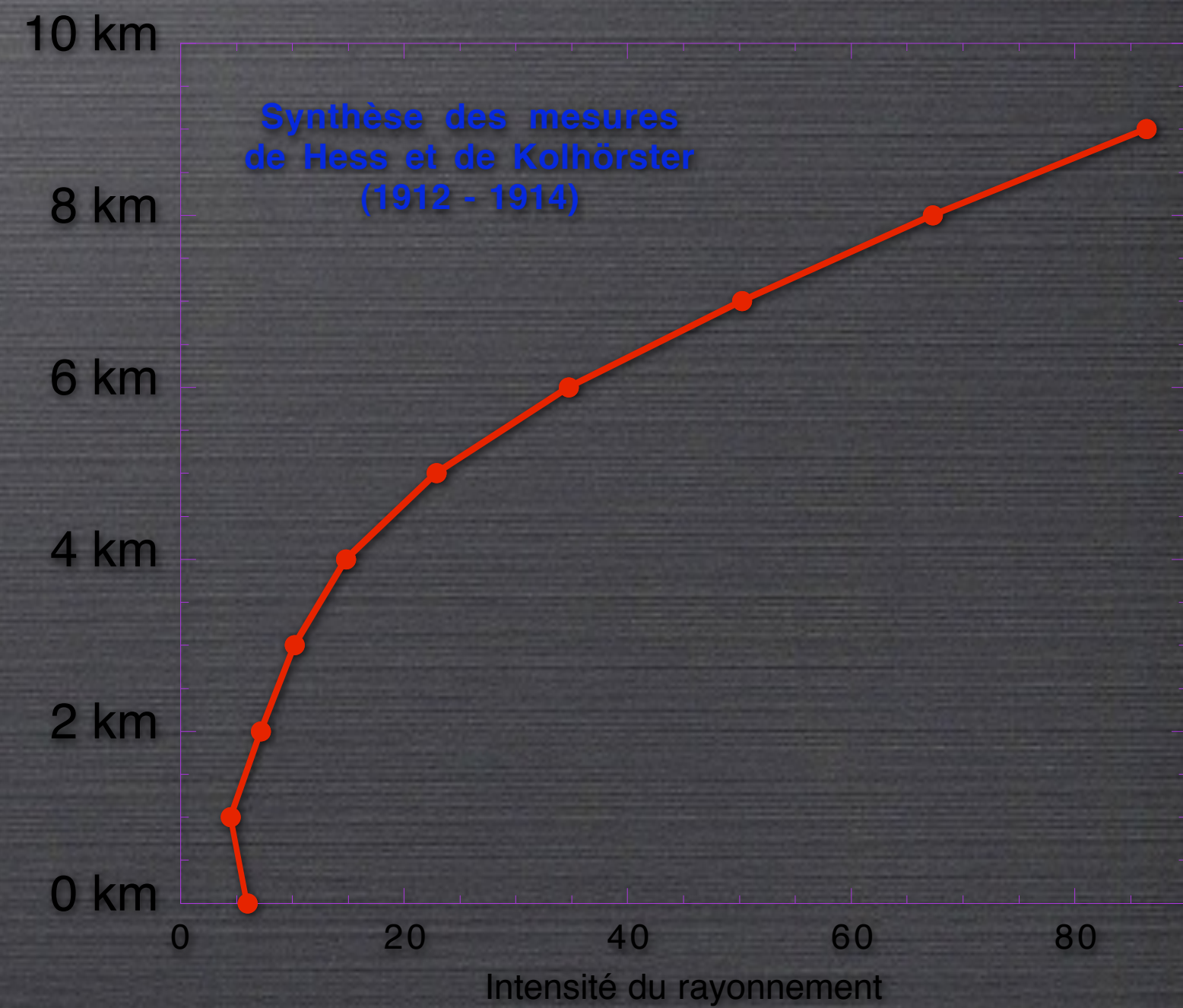
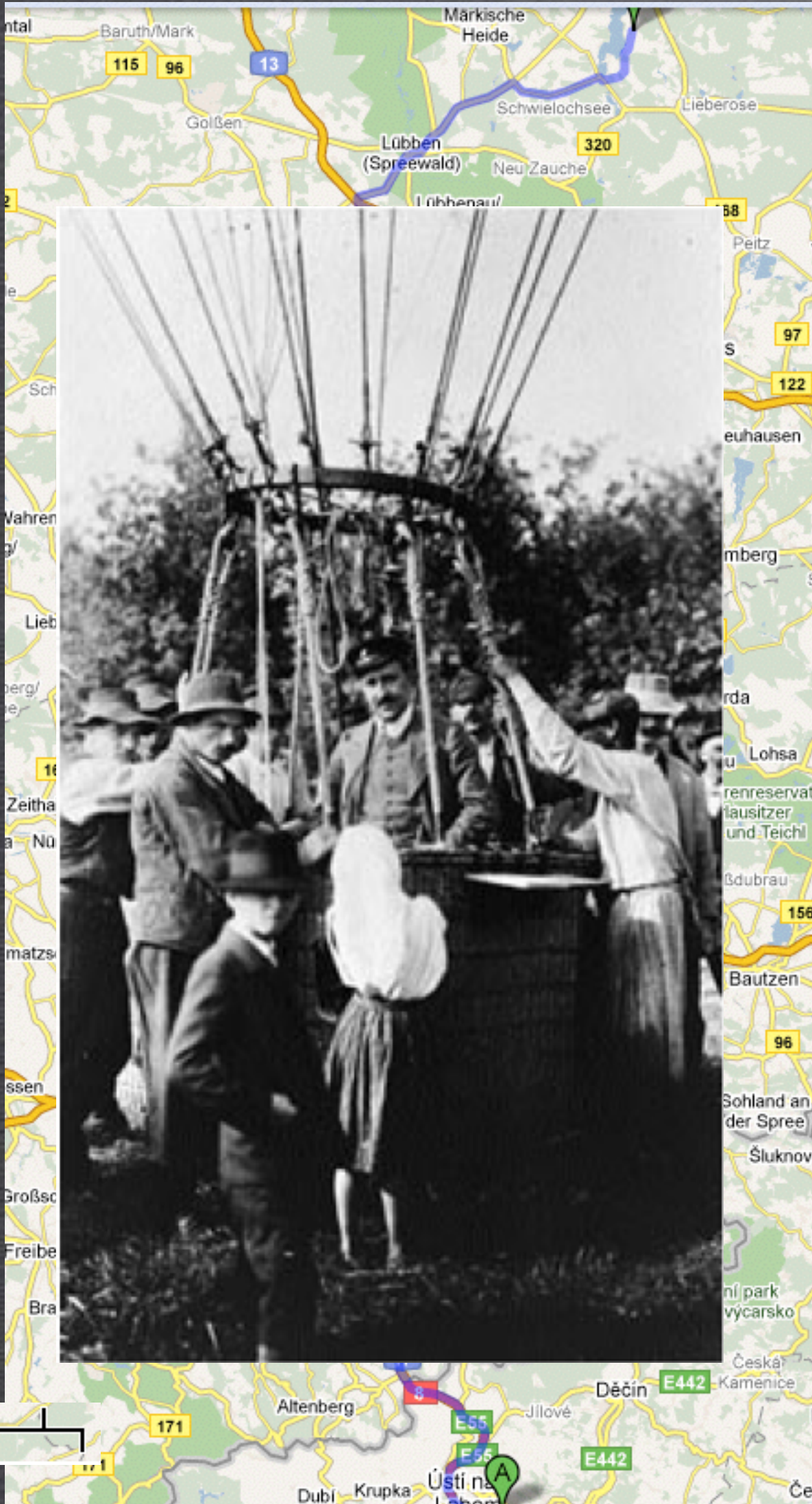
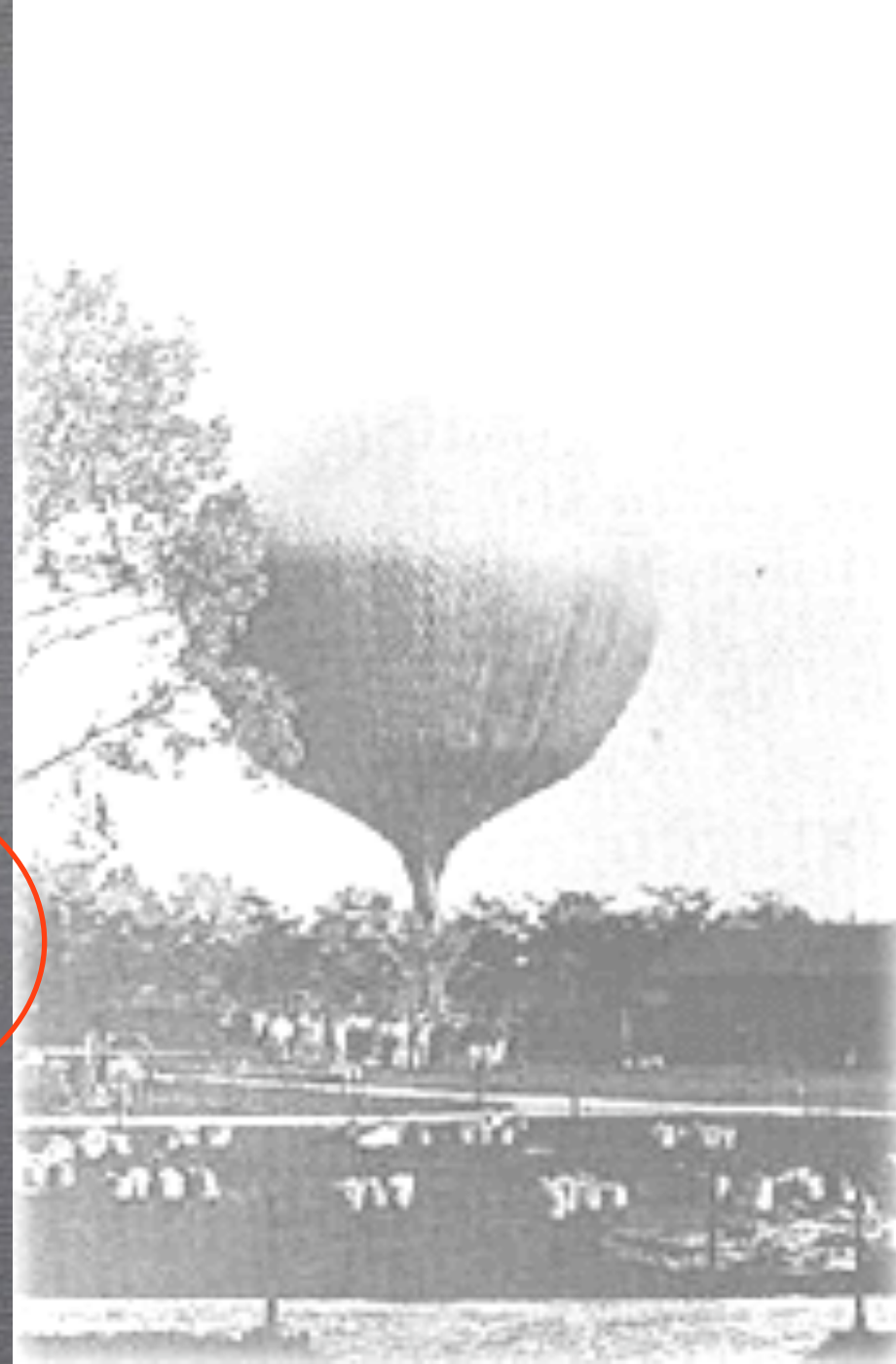
330 m



VICTOR HESS (1912)



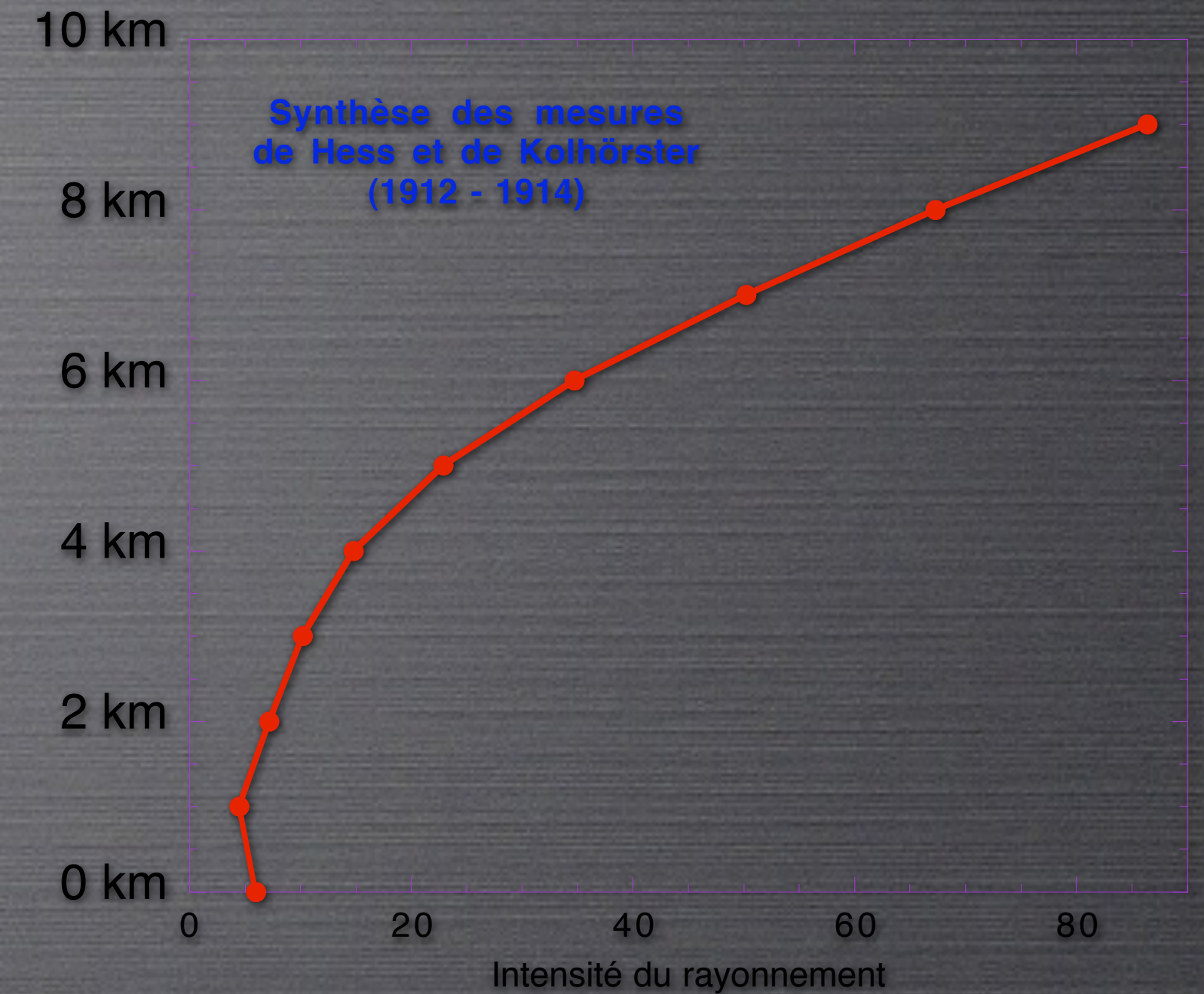
**NOBEL
1936**



VICTOR HESS (1912)



« These observations can be most simply explained assuming that an extremely penetrating radiation is coming from above » (V. Hess)

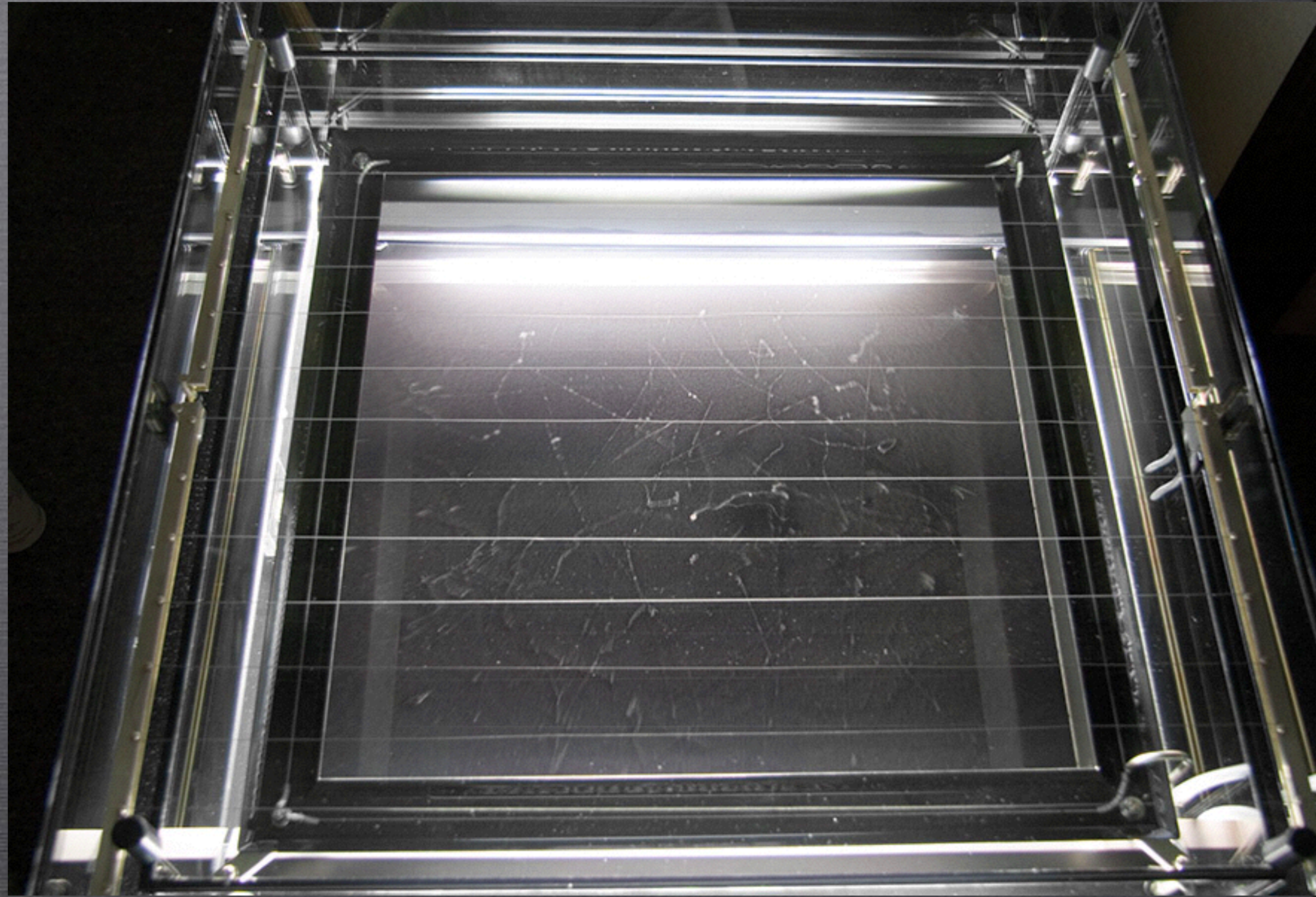


CES OBSERVATIONS S'EXPLIQUE LE PLUS SIMPLEMENT SI ON ADMET QU'UNE RADIATION EXTRÊMEMENT PÉNÉTRANTE ARRIVE PAR LE HAUT

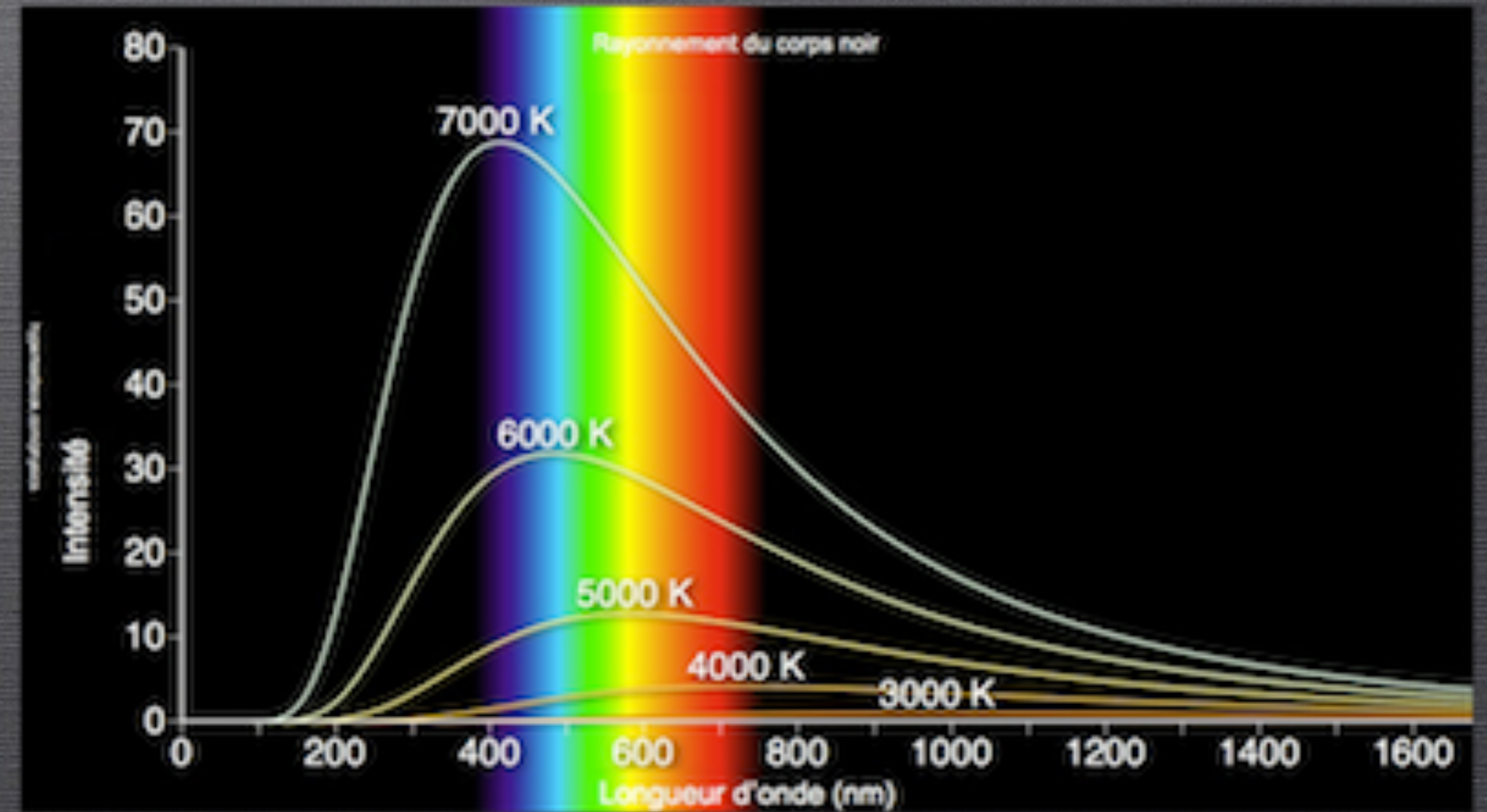
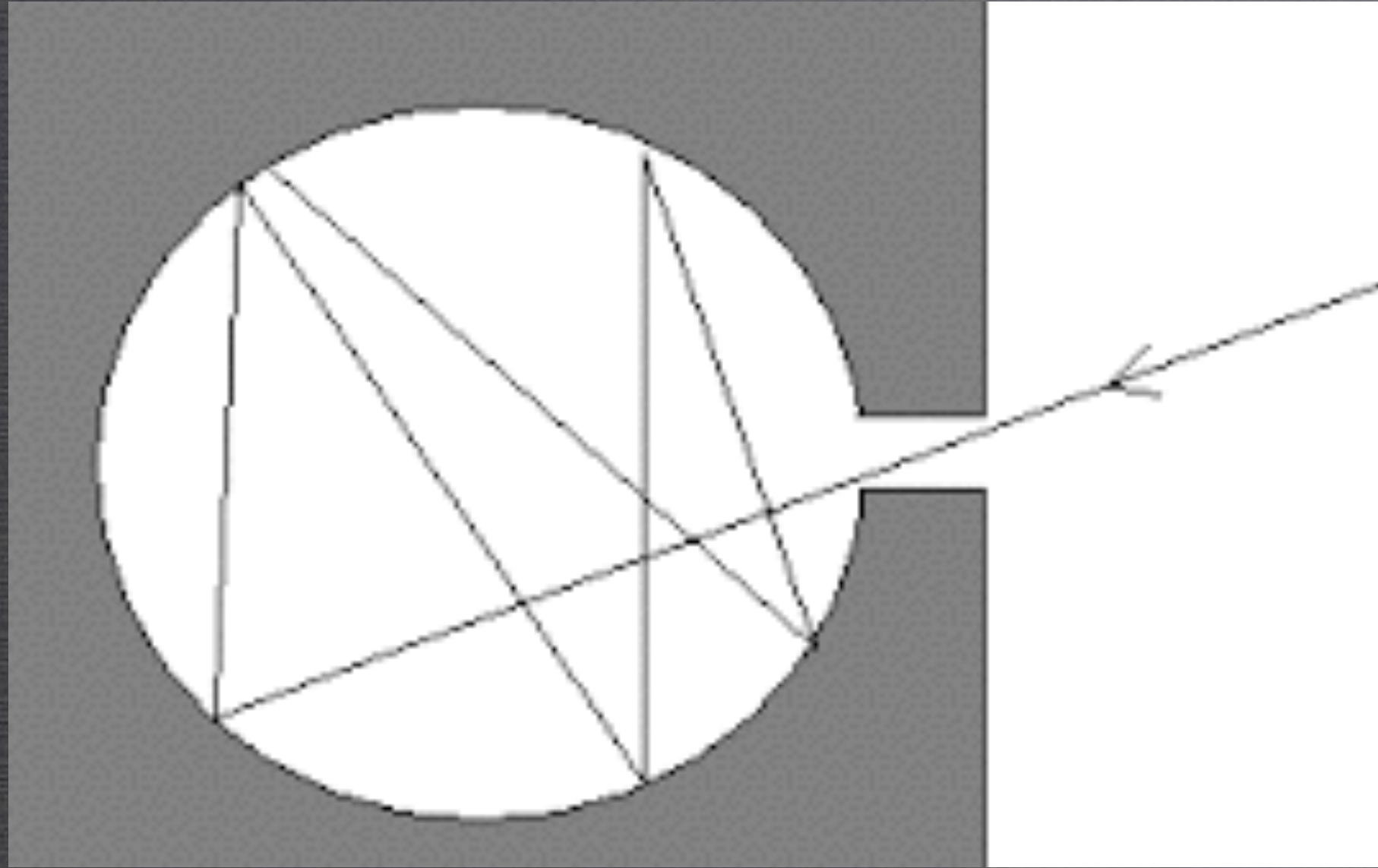
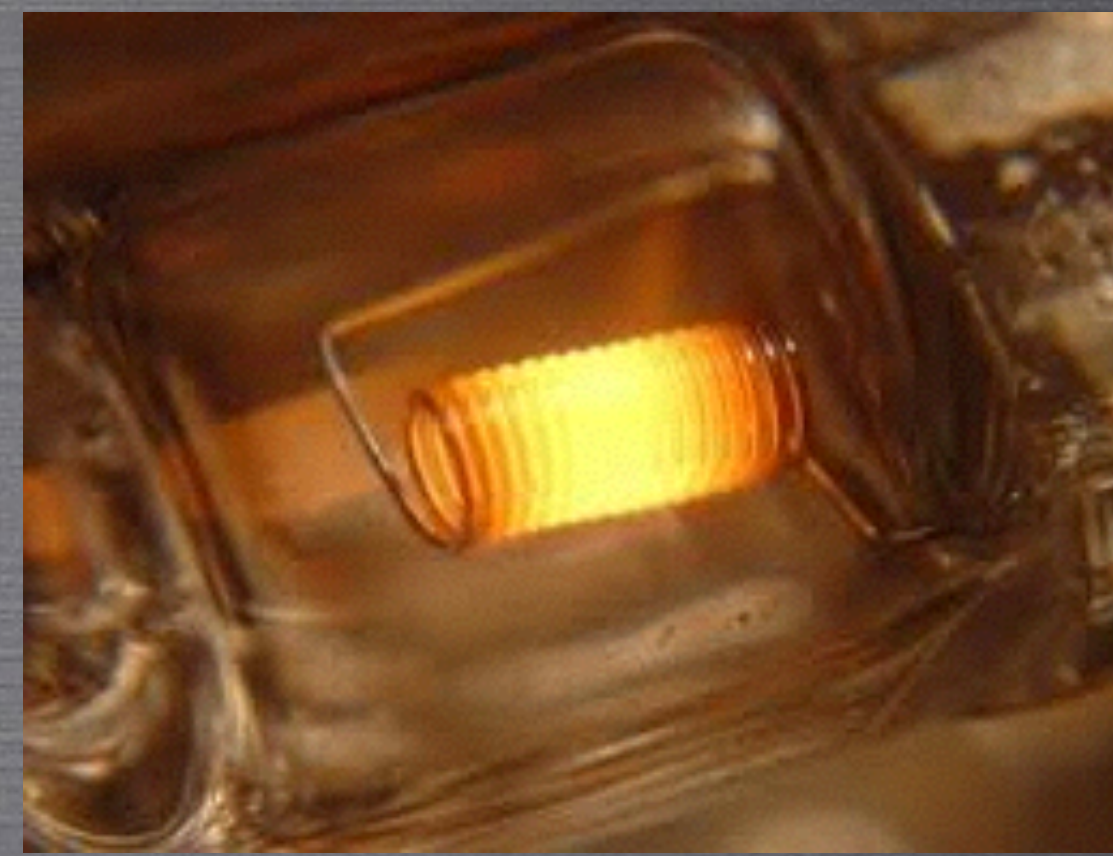
LES NUAGES!



Charles Wilson



CORPS NOIR



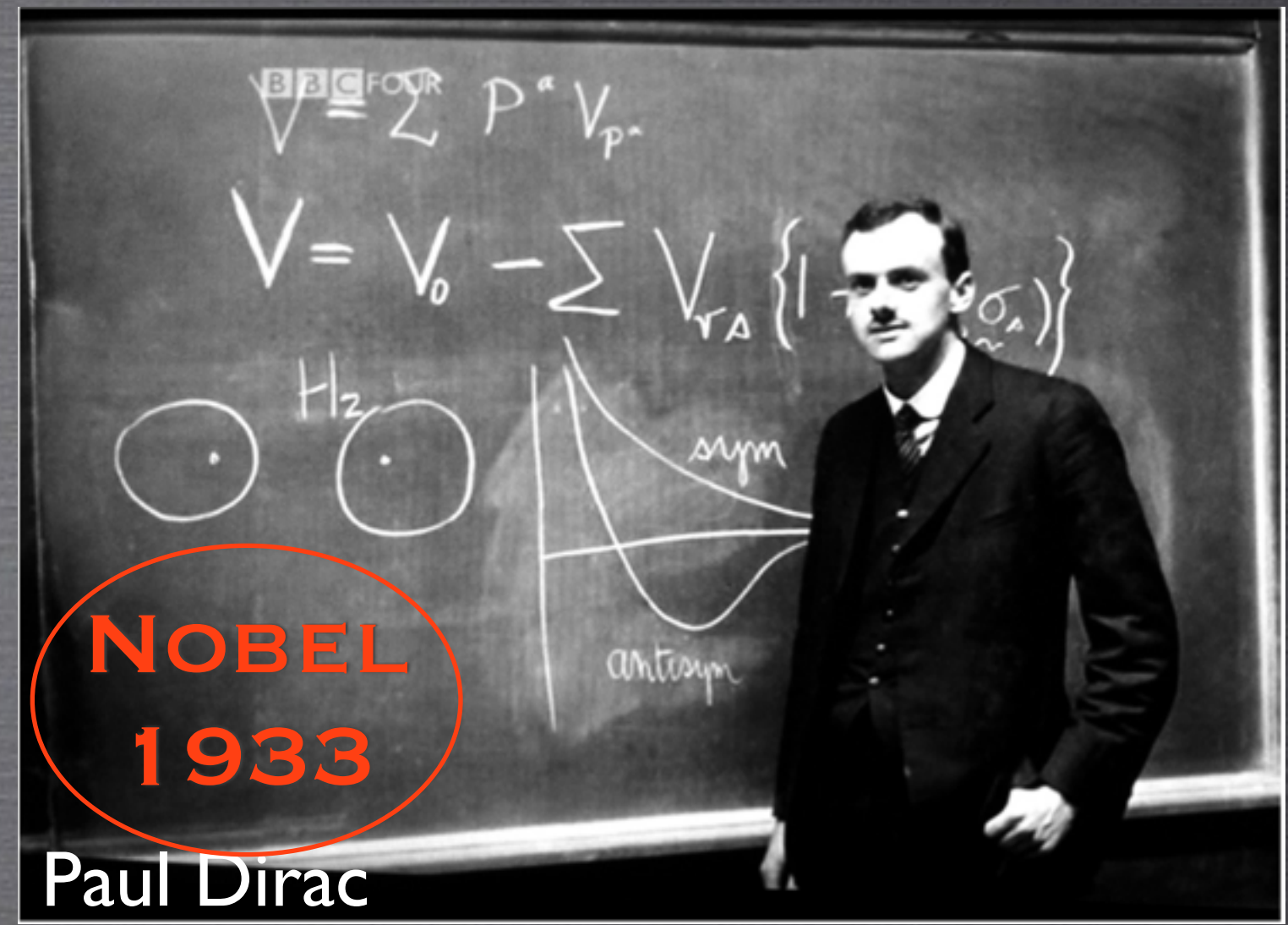
QUANTIQUE



**NOBEL
1918**

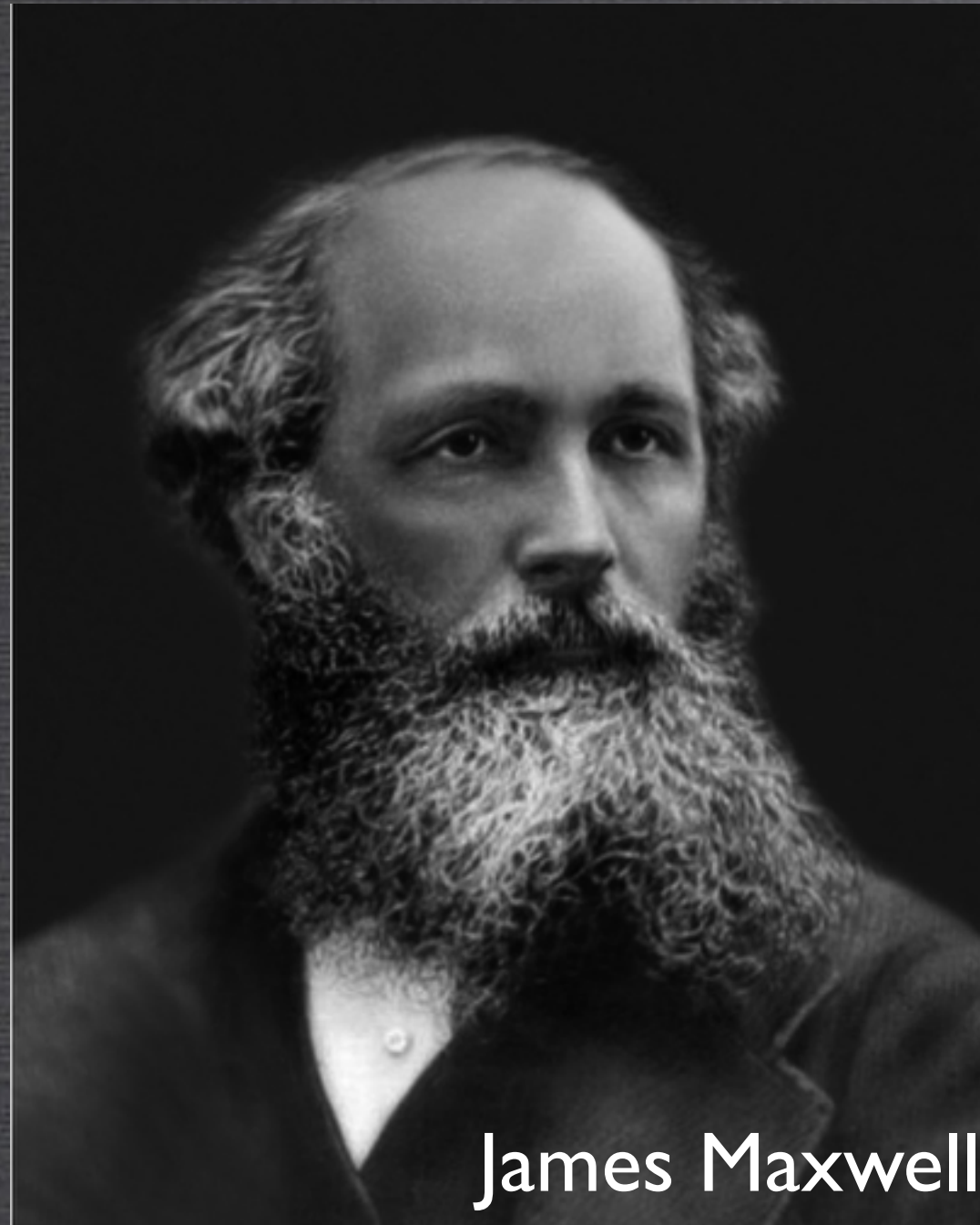


Max Planck

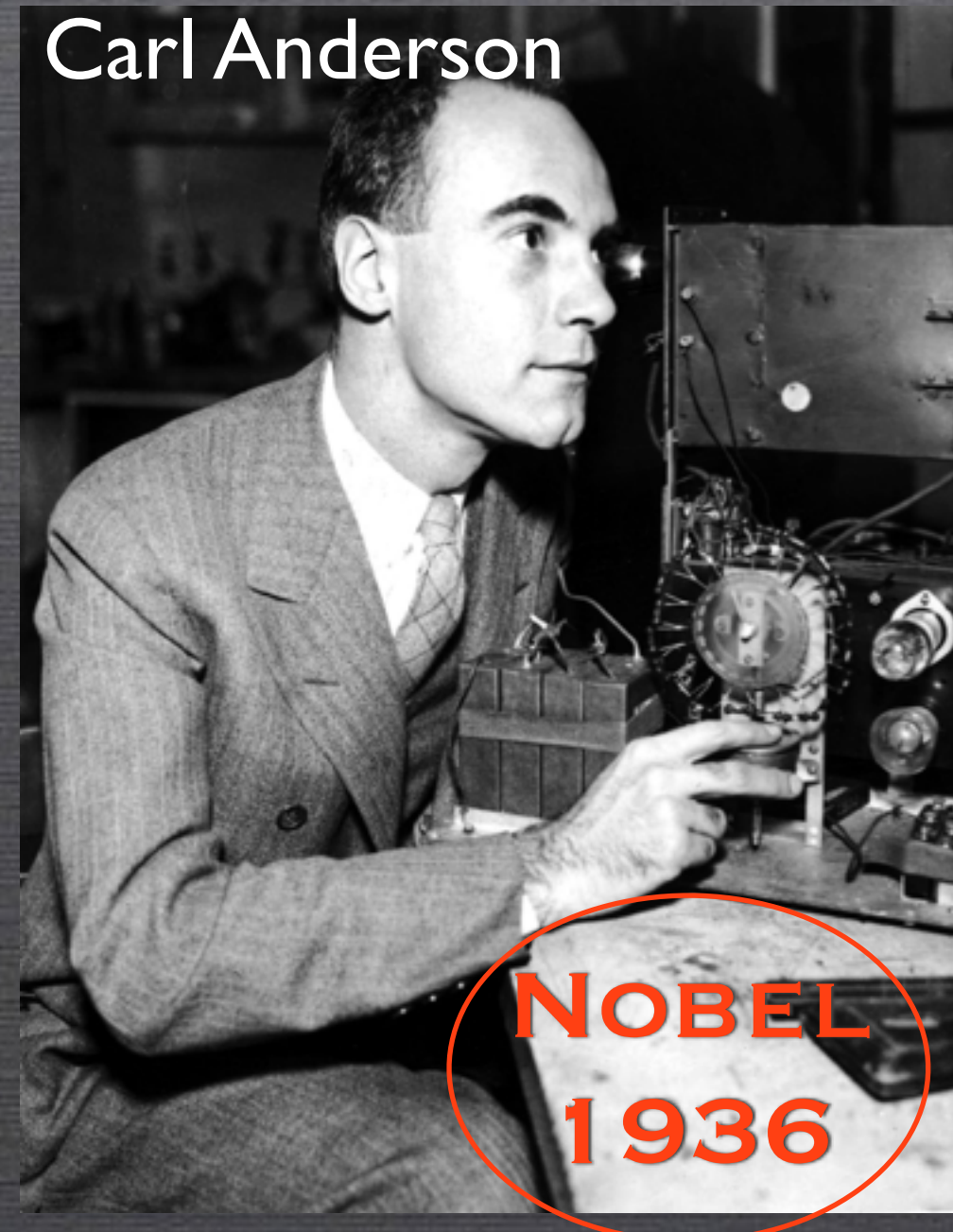


**NOBEL
1933**

Paul Dirac

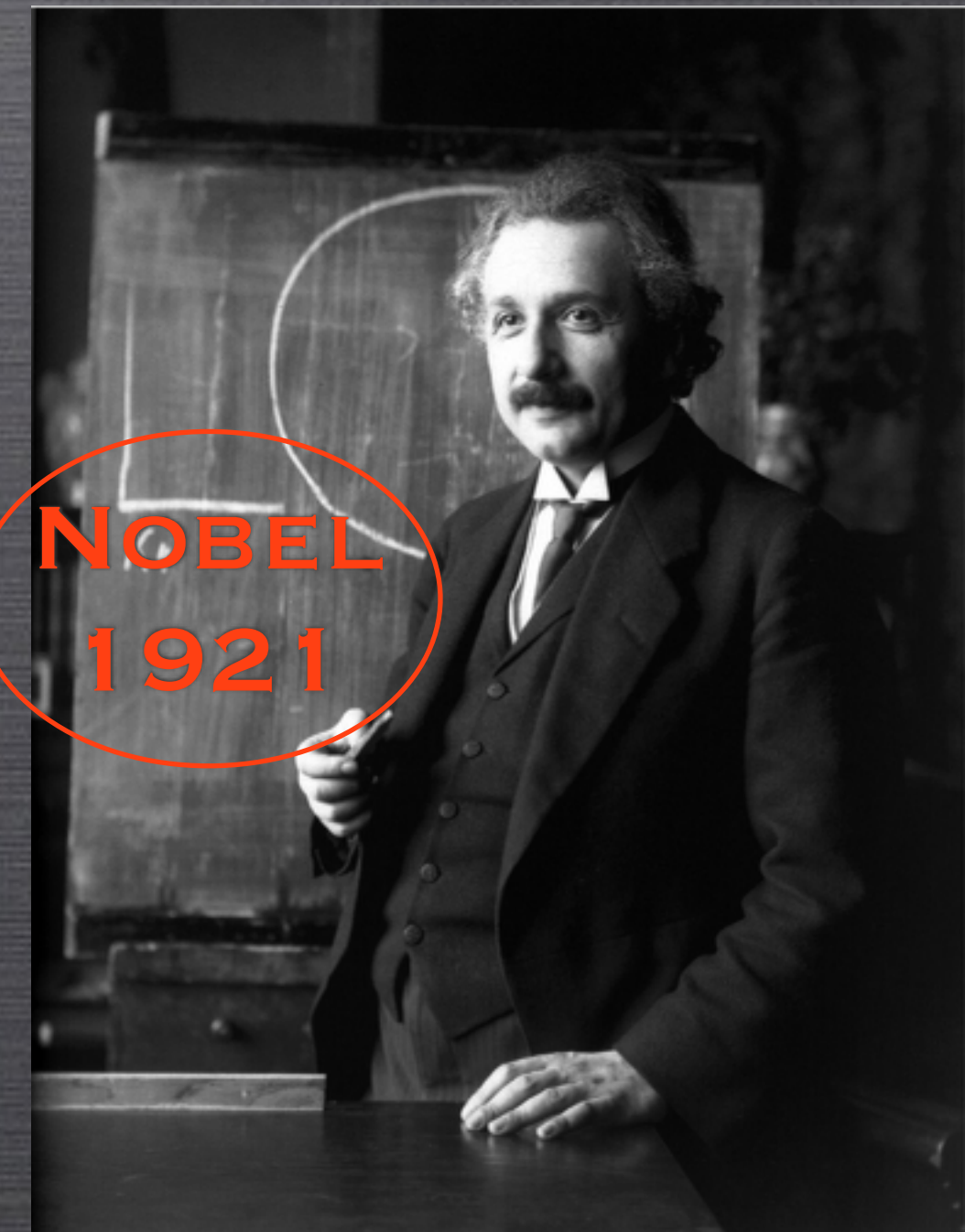


James Maxwell



Carl Anderson

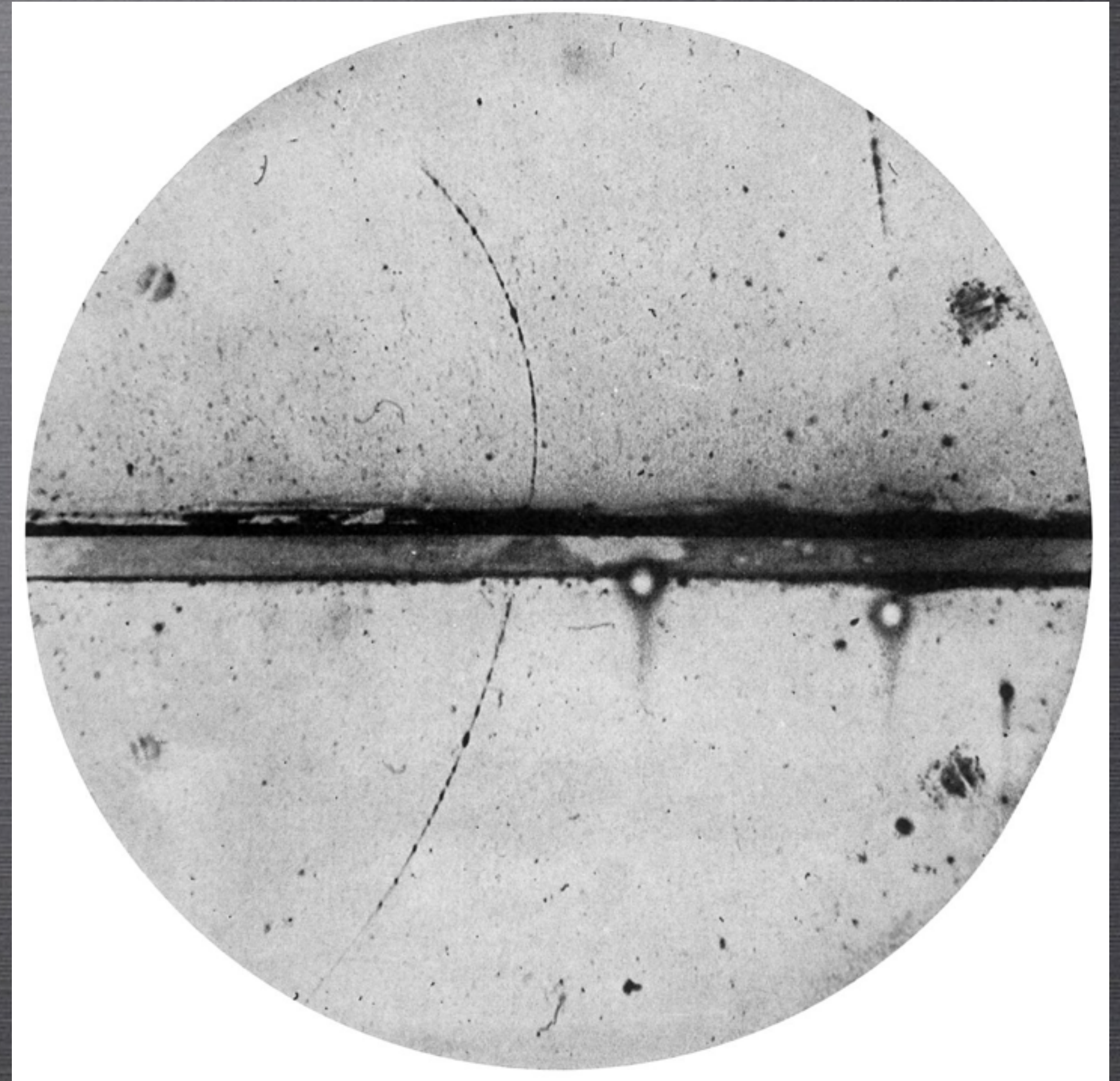
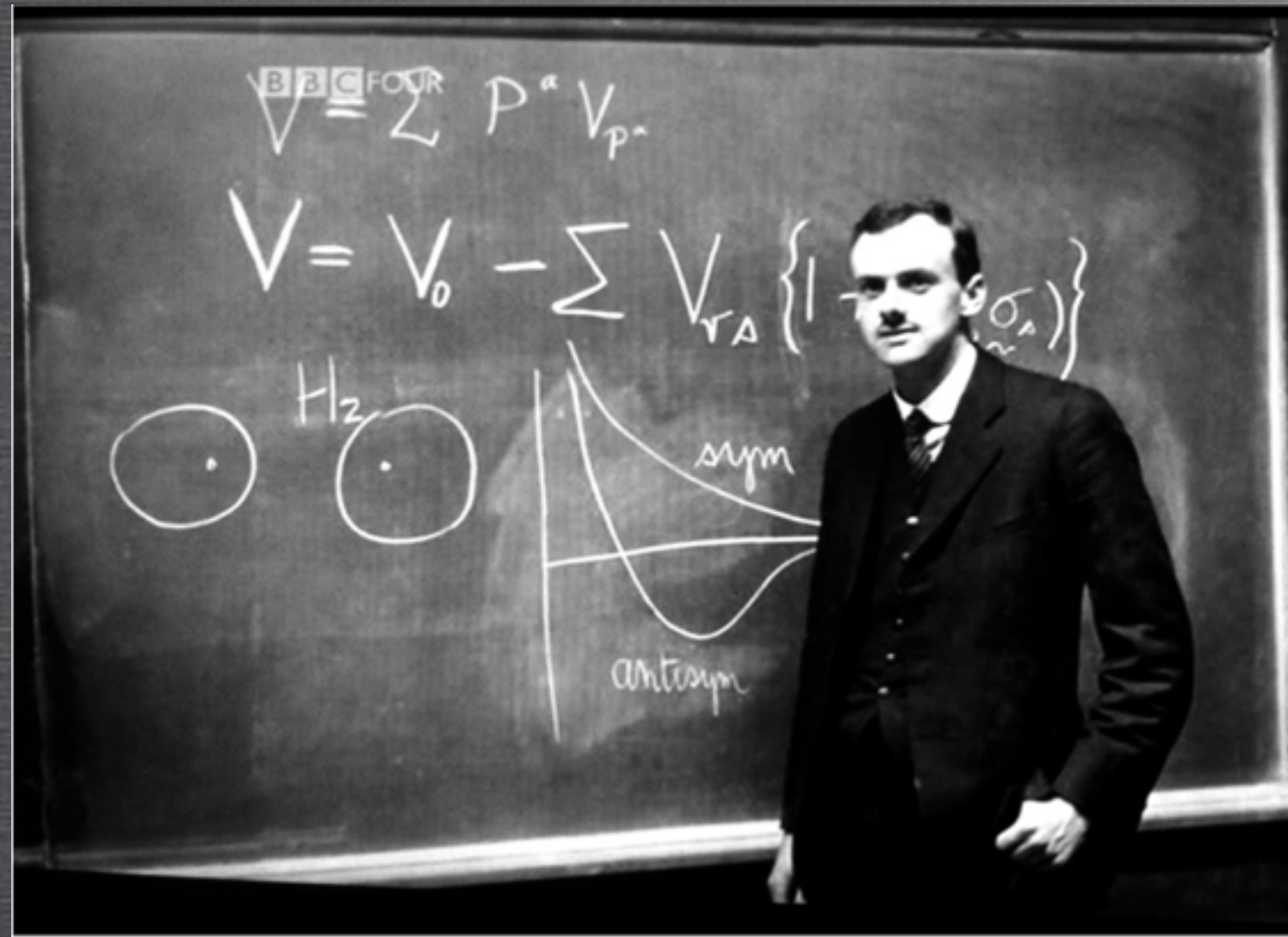
**NOBEL
1936**



**NOBEL
1921**

Albert Einstein

L'ANTIMATIÈRE !



NAISSANCE DE LA PHYSIQUE DES PARTICULES

30 ANS DE DÉCOUVERTES MAJEURES

1913-1914 KOLHÖRSTER CONFIRME L'AUGMENTATION DE L'IONISATION (X7) À 9 KM

1923-1926 MILLIKAN, BOWEN, CAMERON OBSERVENT À 15KM (COUPURE GÉOMAGNÉTIQUE)
NOBEL 1923

RAYON GAMMA TRÈS PÉNÉTRANTS DE HAUTES ÉNERGIES

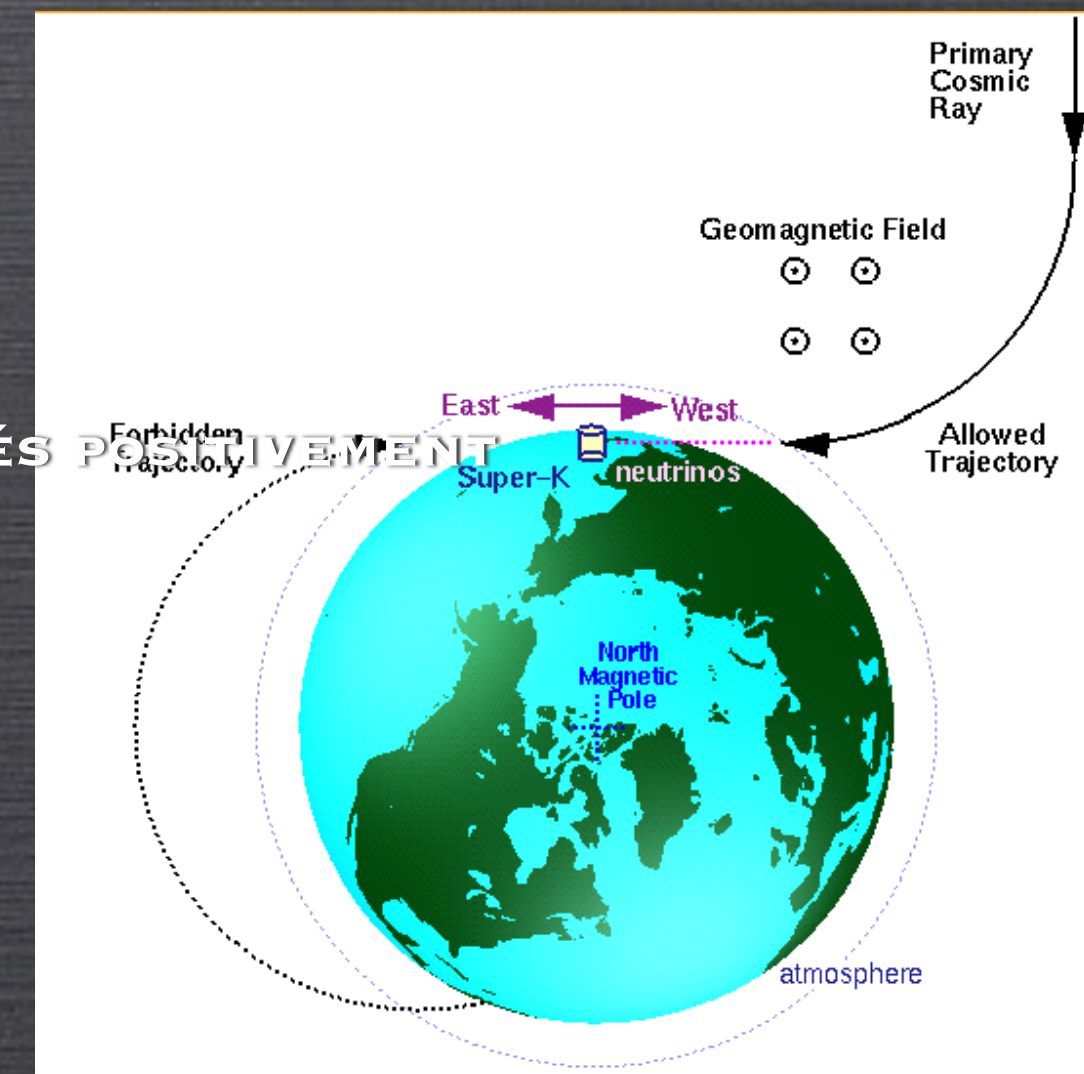
LES RAYONS COSMIQUES

CRI DE NAISSANCE DES ATOMES

1927 CLAY EFFET GÉOMAGNÉTIQUE

1930-1933 ROSSI, JOHNSON, ALVAREZ, COMPTON LES R.C. SONT PRÉFÉRENTIELLEMENT CHARGÉS POSITIVEMENT
NOBEL 1927

1927: During his trip from Amsterdam to Java, **S. Clay** – by carrying ionization detectors onboard ships – discovered that the ionization rate increased with latitude. It was the first observation of a **geomagnetic latitude effect** and very important evidence that the sources of ionization were, at least in part, **charged particles** deflected by an external field. In the period from **1928** to **1932** Clay investigated the latitude effect further by taking the ionization chamber on 3 sea voyages between Europe and Java via the Suez Canal. He again found a consistently lower intensity near the equator.
1930: **Bruno Rossi**, using **Störmer's theory**, showed that if the cosmic rays were predominantly of one charge or the other there should be an **east-west effect**.
1933: Two American groups, **Thomas H. Johnson** of the Bartol Research Foundation and **Luis Alvarez** and **Arthur H. Compton** of the University of Chicago, simultaneously and independently measured the east-west effect **predicted by Rossi**. It showed the cosmic radiation to be predominantly **positively charged**.



1932 **ANDERSON** DÉCOUVRE L'ANTIMATIÈRE (LE POSITRON) ORÉDIT PAR DIRAC EN 1928

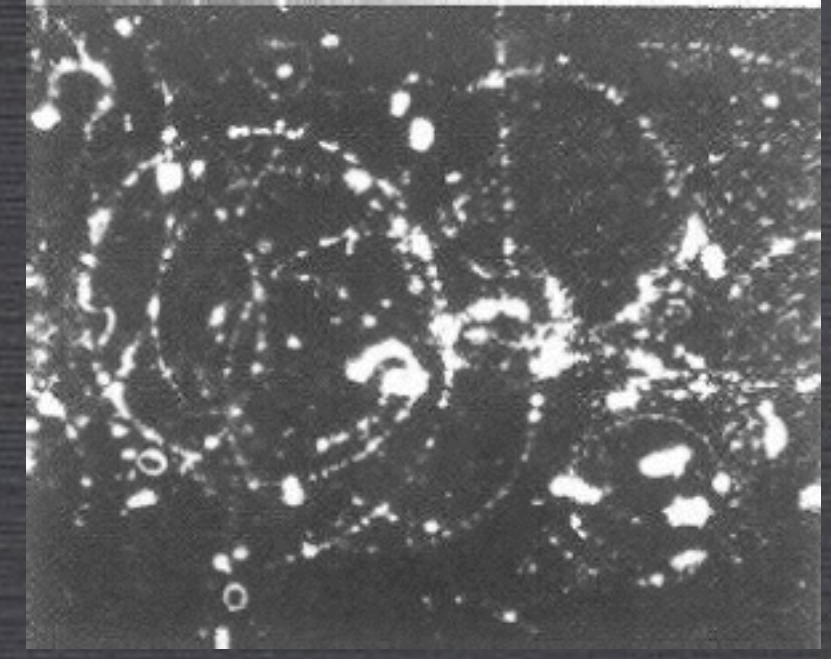
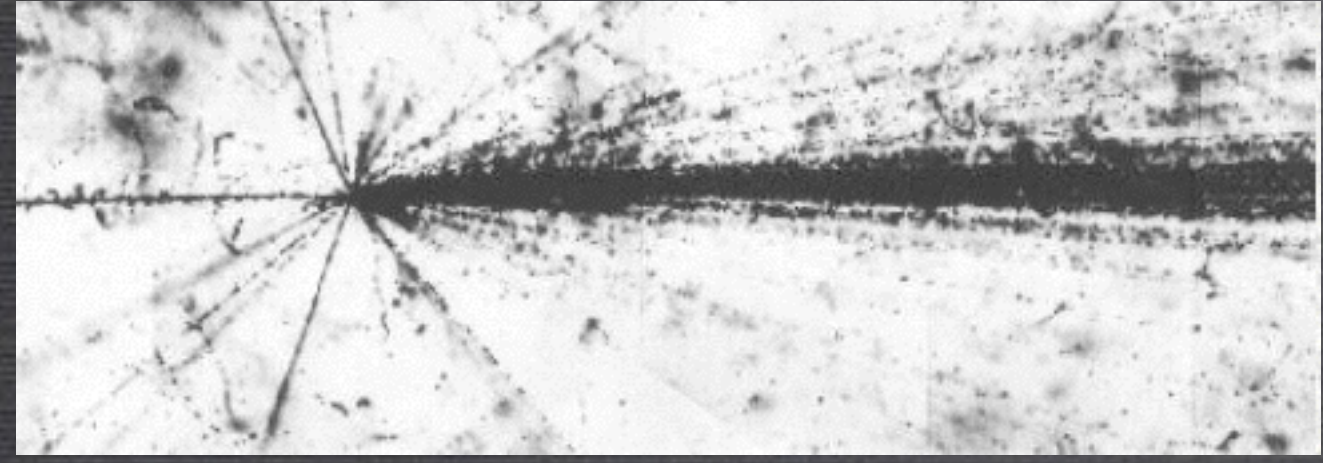
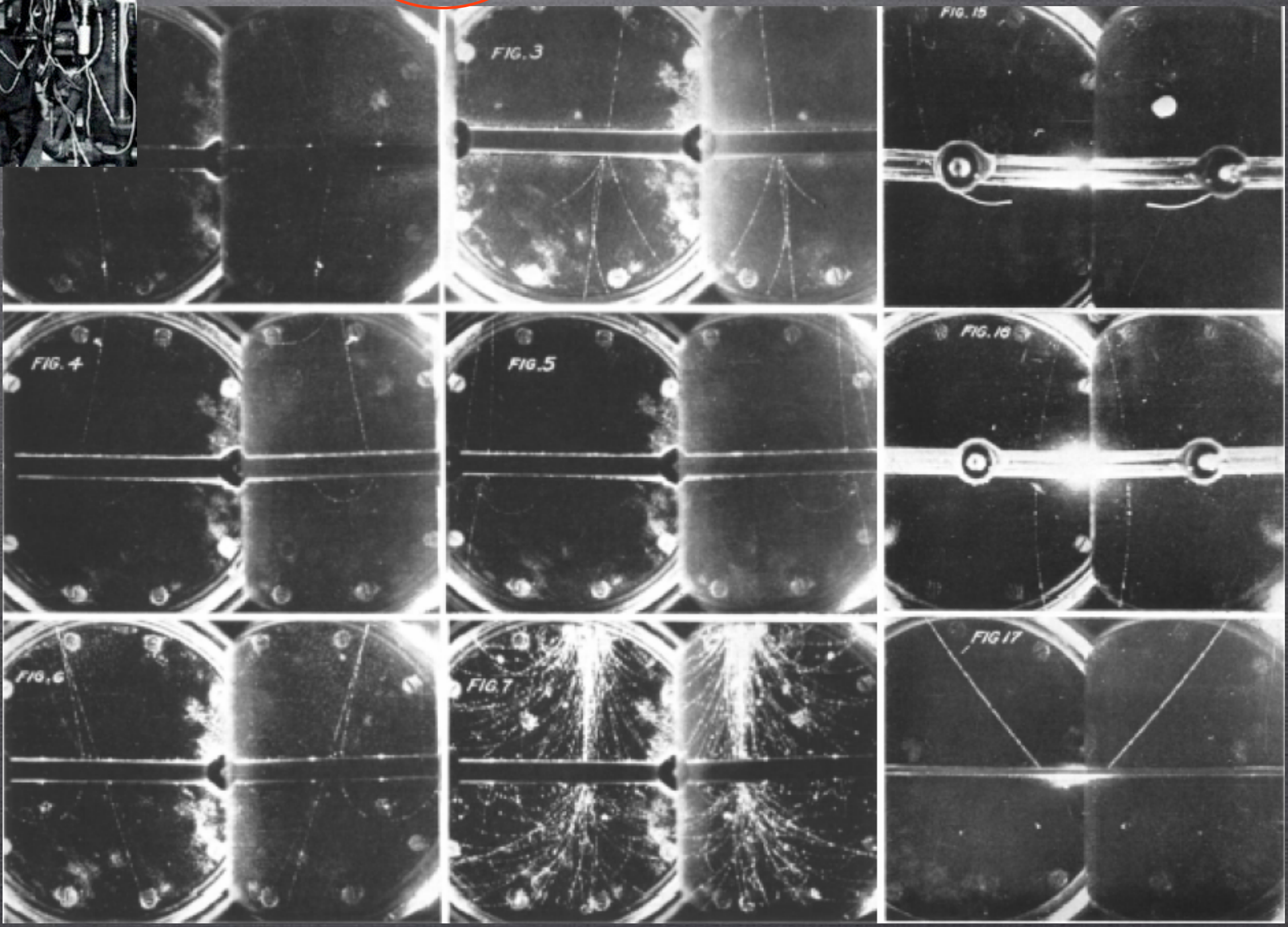
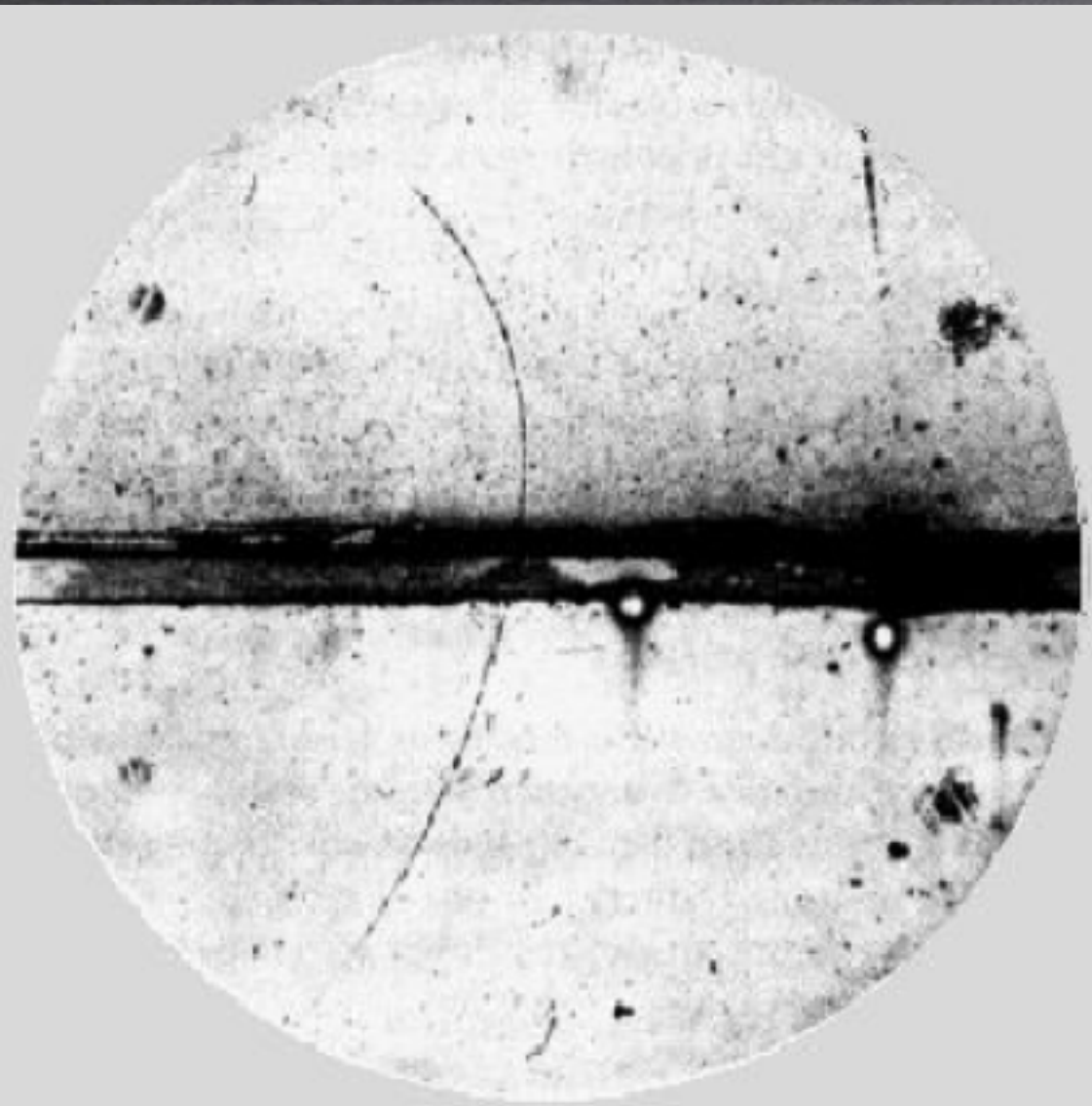
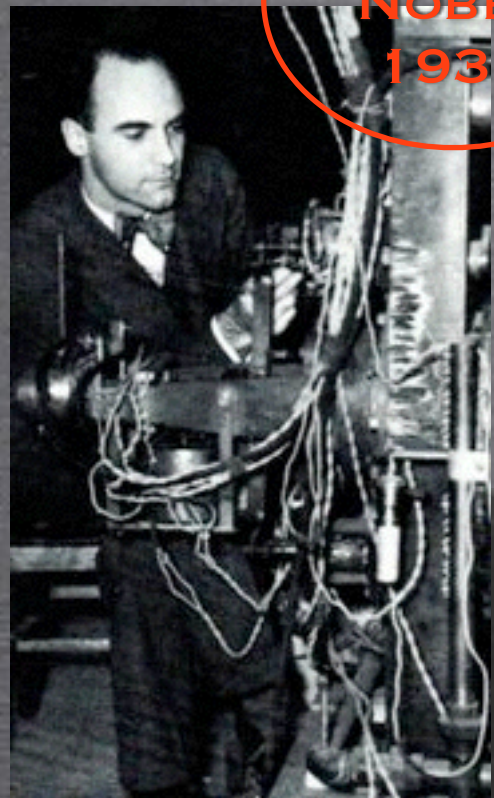
**NOBEL
1936**

1932 **ANDERSON & NEDDERMEYER** DÉCOUVRE LE MUON

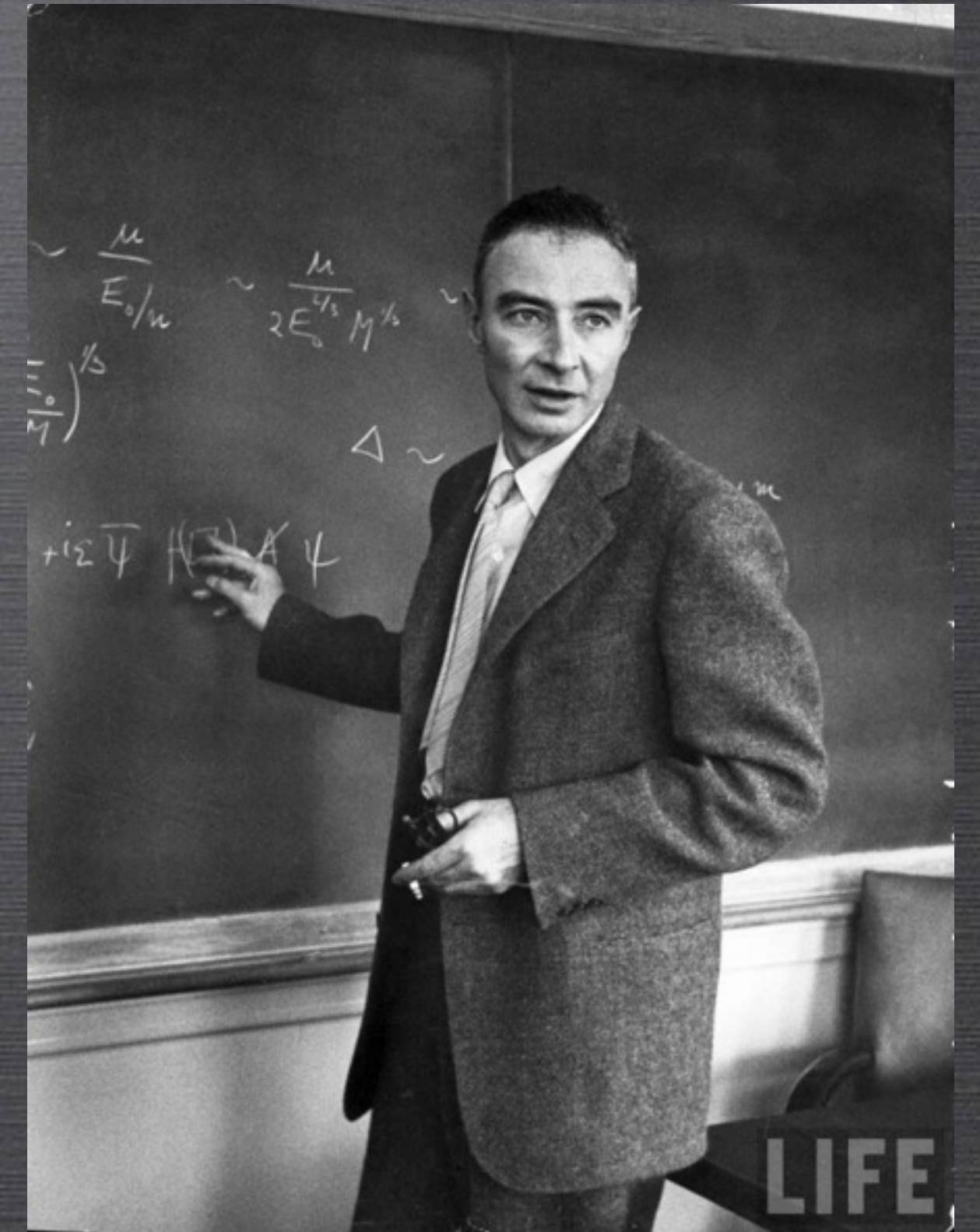
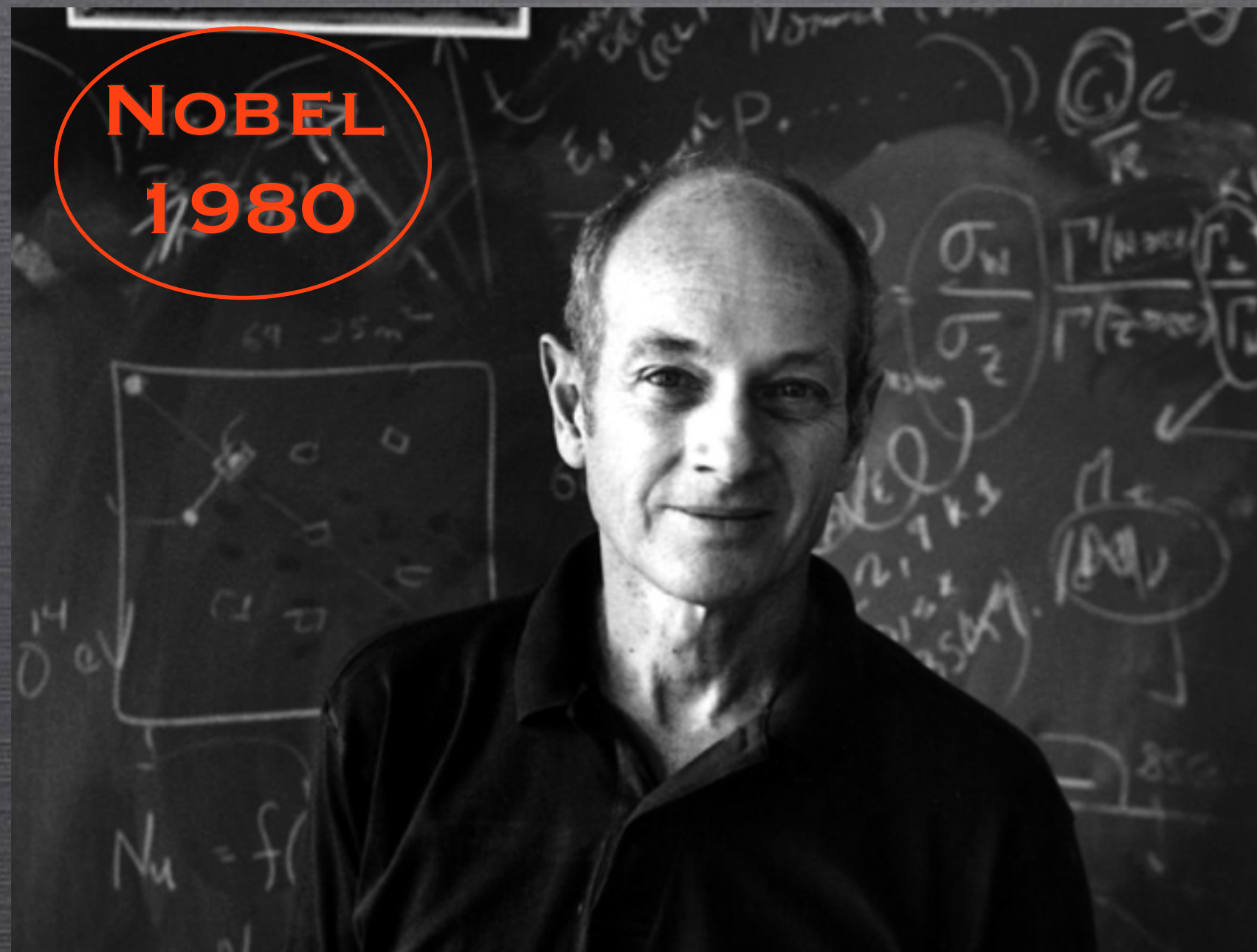
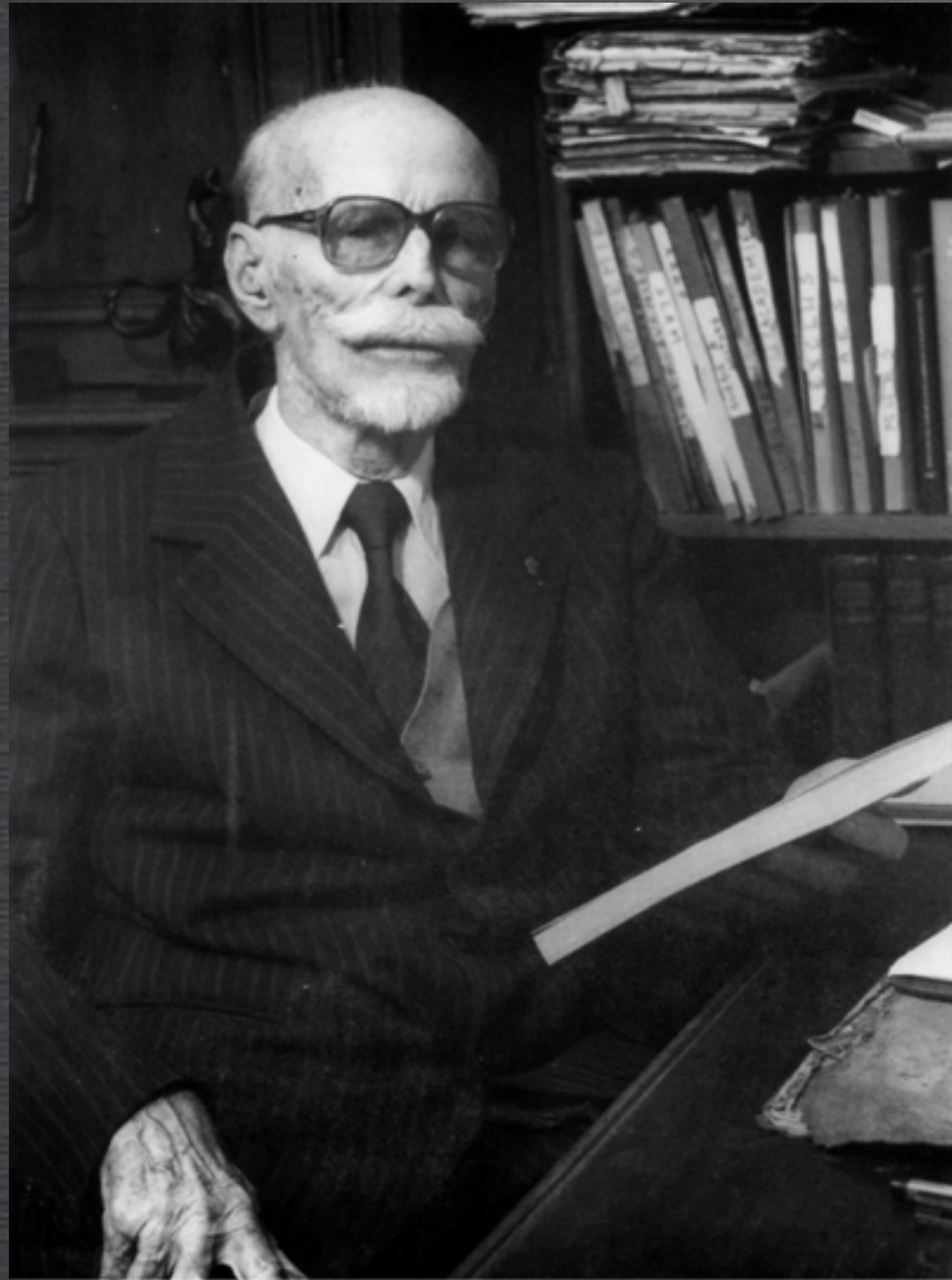
1947 **POWELL, LATTES & OCCHIALINI** DÉCOUVRE LE PION

**NOBEL
1950**

+ ...

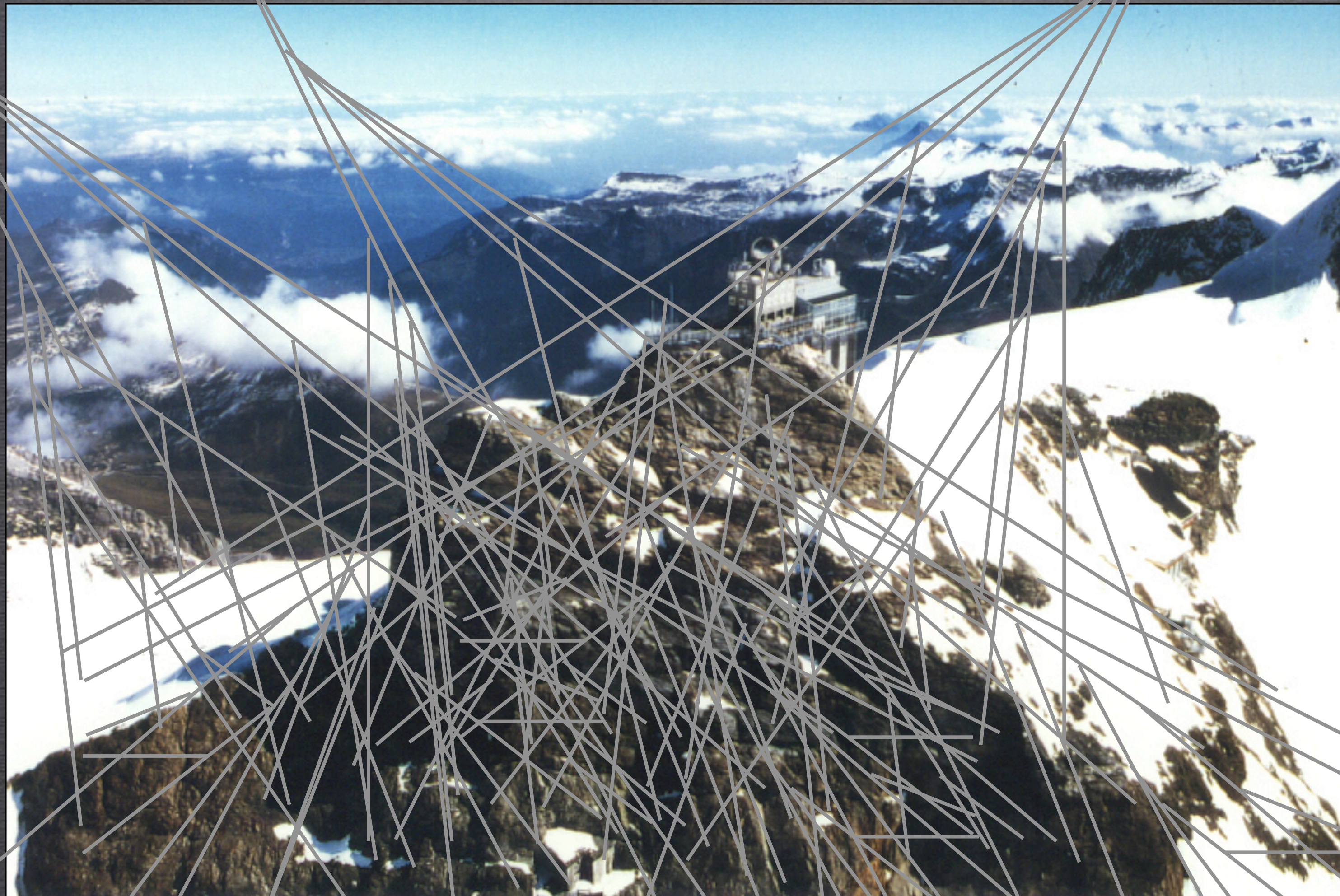


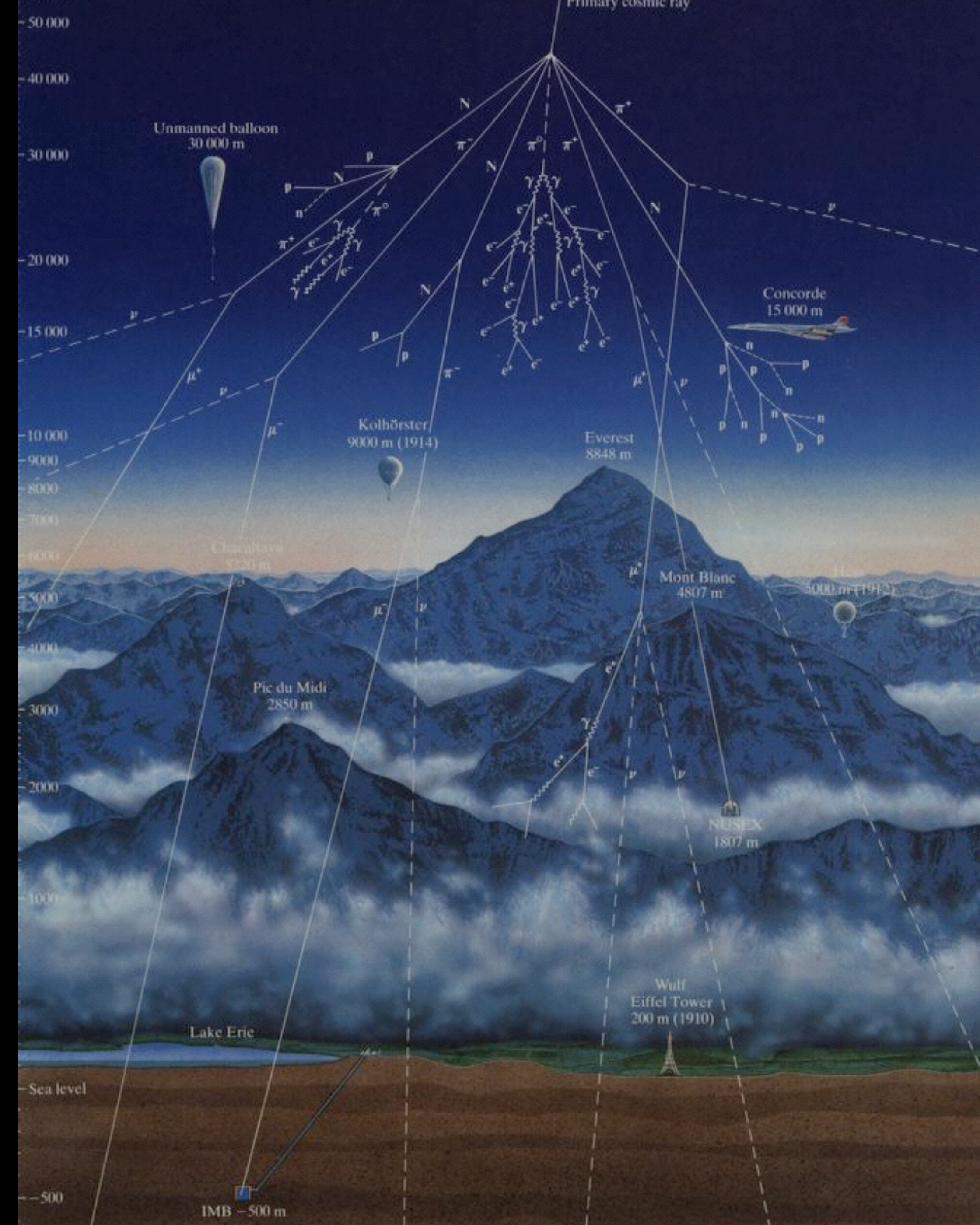
CASCADES



PIERRE AUGER (1938)

DÉCOUVERTE DES GRANDES GERBES
ATMOSPHÉRIQUES





1960

GRAND

JOHN LINSLEY (1962) - VOLCANO RANCH - NOUVEAU MEXIQUE



The Volcano Ranch Array near Albuquerque, New Mexico



UN PROTON DE 10^{20} eV

(100 000 000 000 000 000 000 000 eV)

C'EST :



L'ÉNERGIE DE MYKE TYSON DANS UNE PARTICULE
ÉLÉMENTAIRE

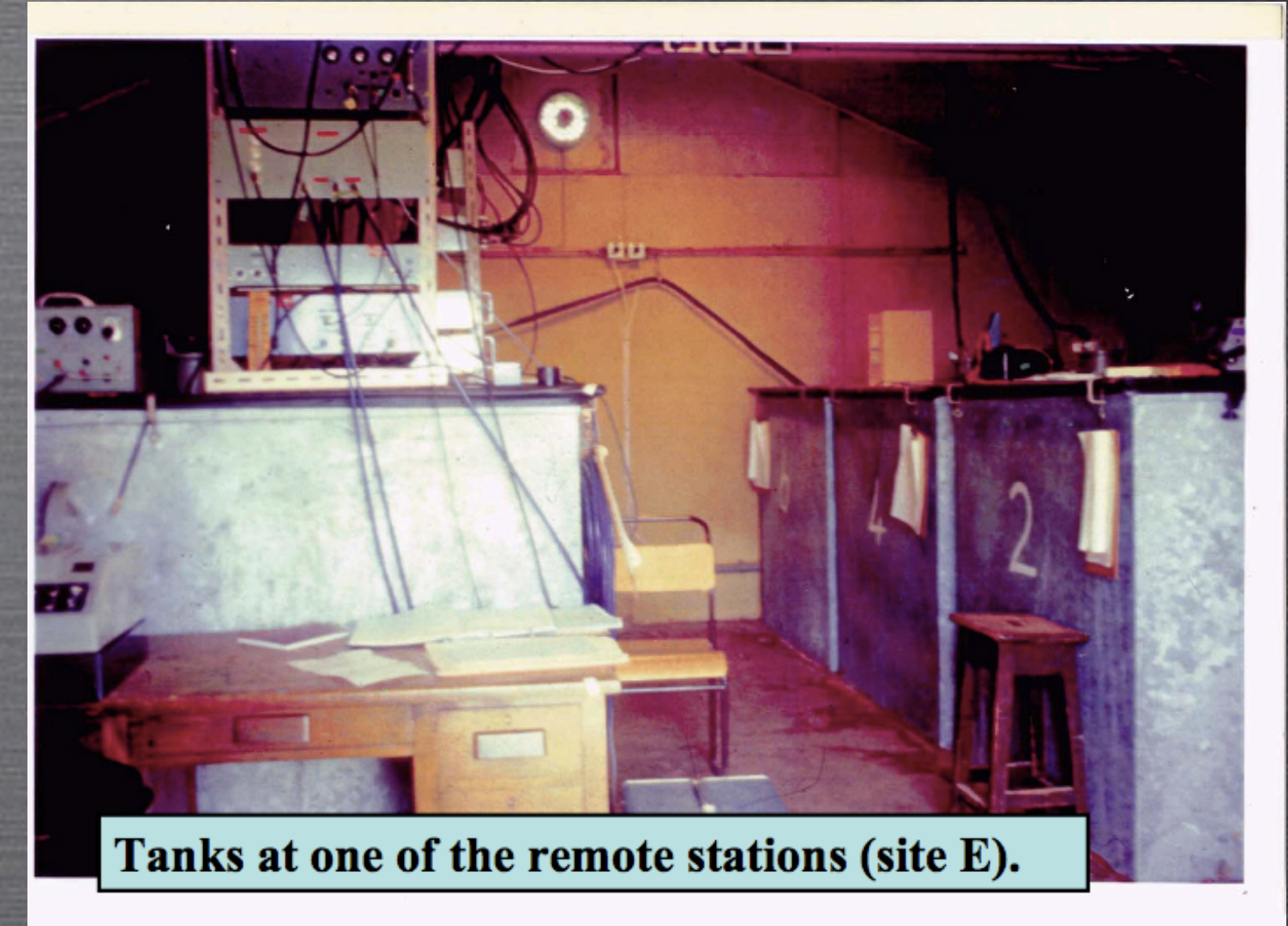
3×10^{20} eV = 50 joules = 1 Tyson ©

250 TONNES POUR UN SIMPLE MOUSTIQUE S'IL VOYAGEAIT À
LA MÊME VITESSE QUE CES PROTONS COSMIQUES

1 G D'ENTRE EUX PERMETTRAIT D'ALIMENTER LA FRANCE EN
ÉLECTRICITÉ PENDANT PRÈS DE 6 MILLIONS D'ANNÉES.

(MAIS ILS SONT RARE, IL FAUDRAIT PLUS DE DIX MILLIONS DE
FOIS L'ÂGE DE L'UNIVERS POUR EN RECUEILLIR AUTANT)

LE RÉSEAU D'HAVERAH PARK - ÉCOSSE - 1960-1987



YAKUTZ

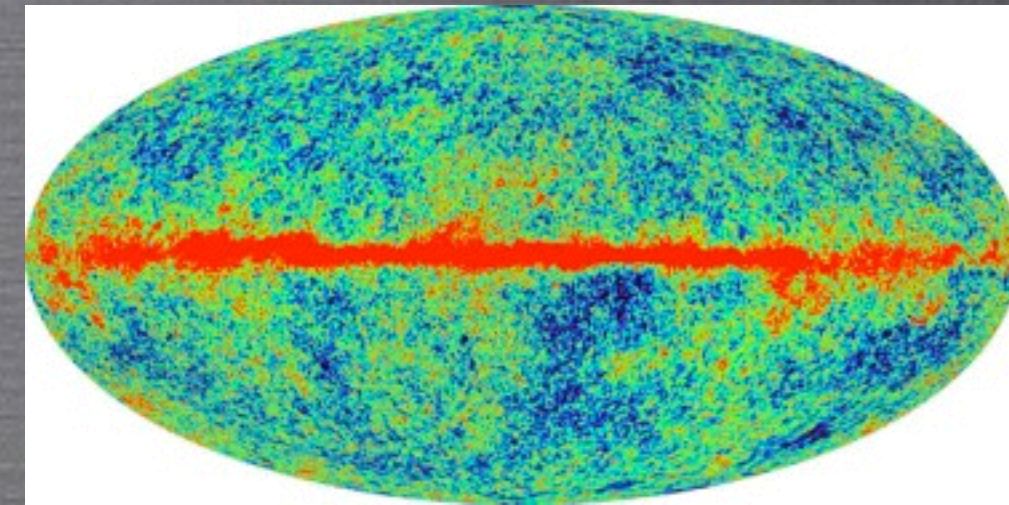


EN 1966 DÉCOUVERTE DU FOND COSMOLOGIQUE DE RADIATION



PENZIAS & WILSON

**NOBEL
1978**



À TRÈS HAUTES ÉNERGIES L'UNIVERS DEVIENT OPAQUE

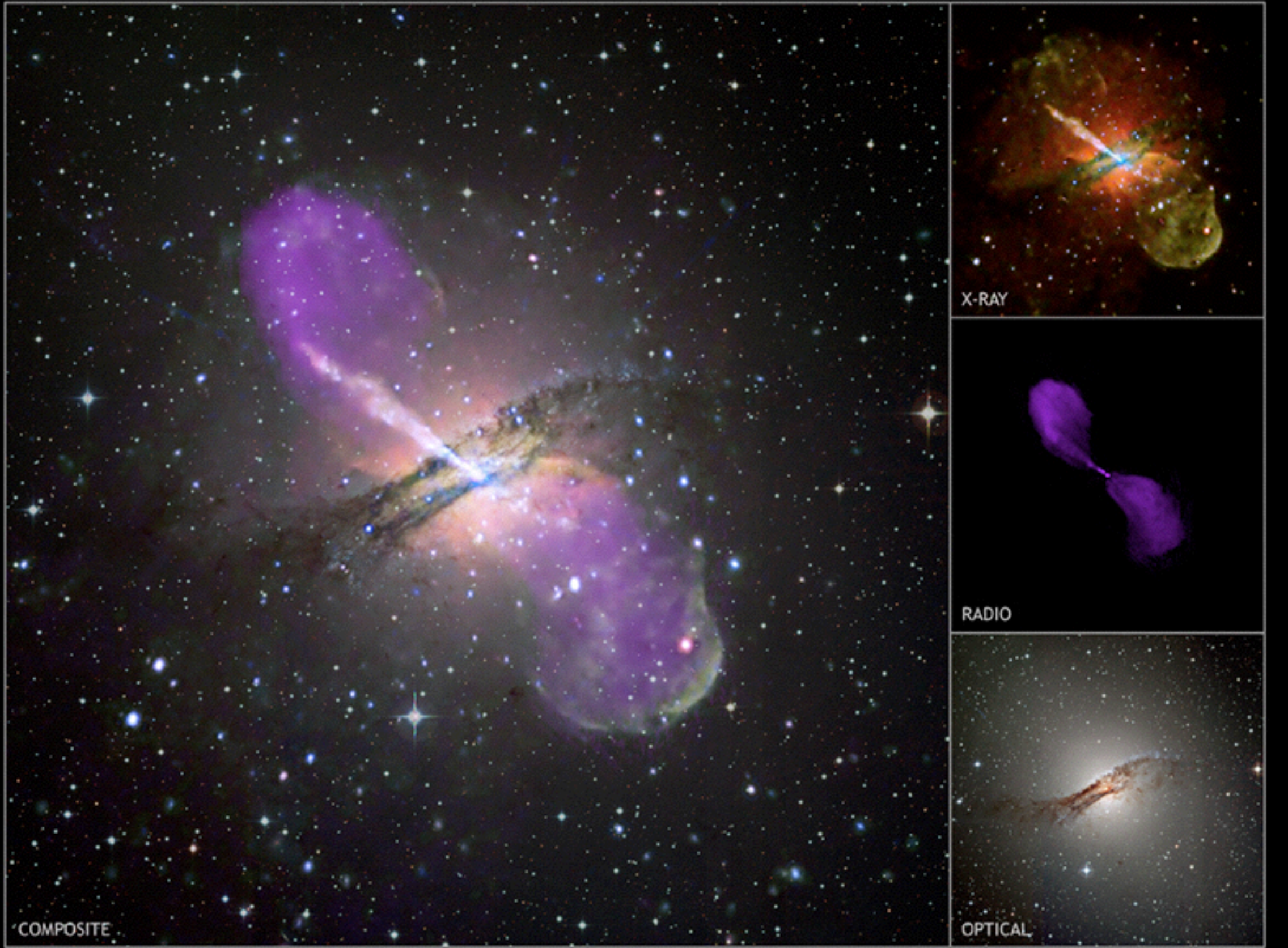
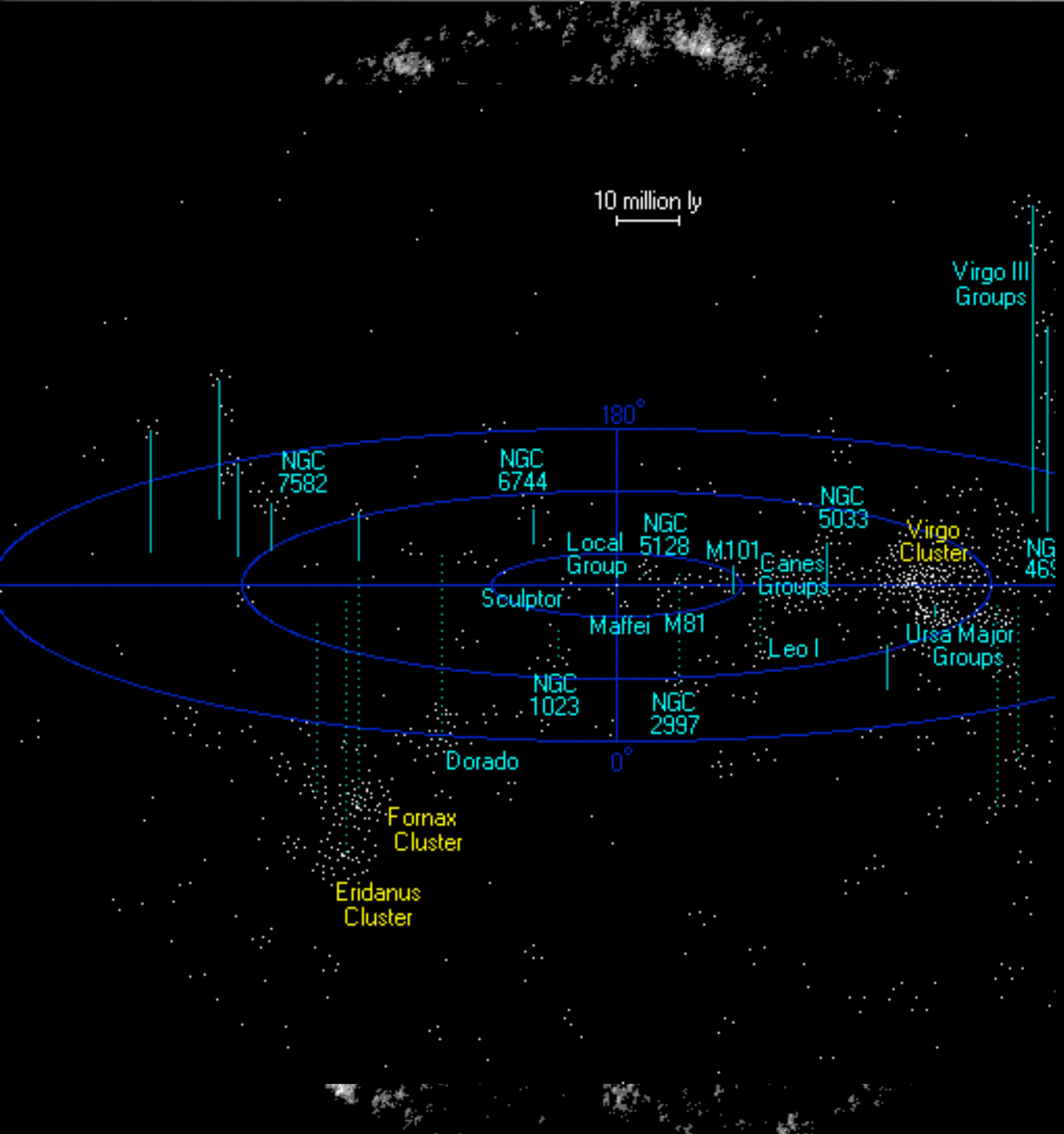
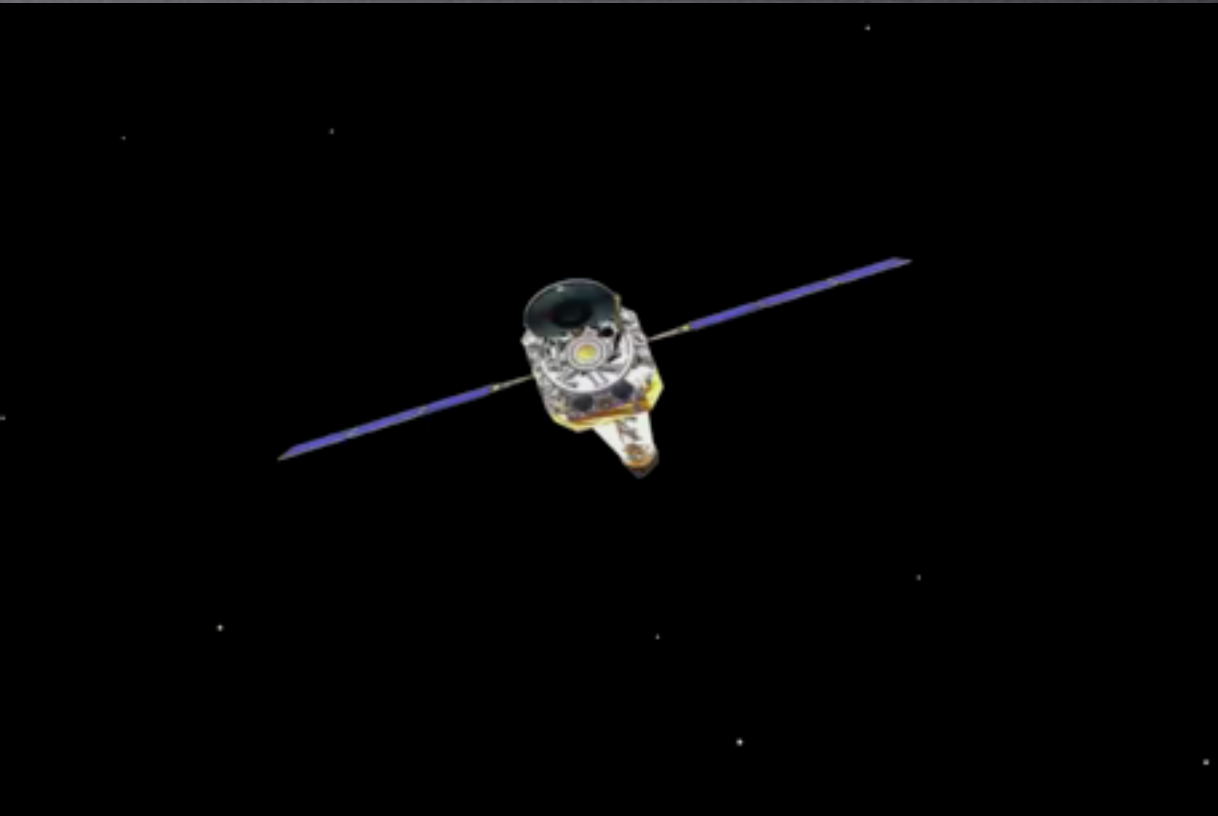
✦ LE FLUX DE RAYONS COSMIQUE DEVRAIT DISPARAÎTRE

PRÉDICTION DE GREISEN ZATSEPIN & KUZMIN [GZK]

✦ SI DES PARTICULES DE TRÈS HAUTES ÉNERGIES
SUBSISTENT LES SOURCES SONT PROCHE

ON PEUT LES RECHERCHER SUR LE CIEL !

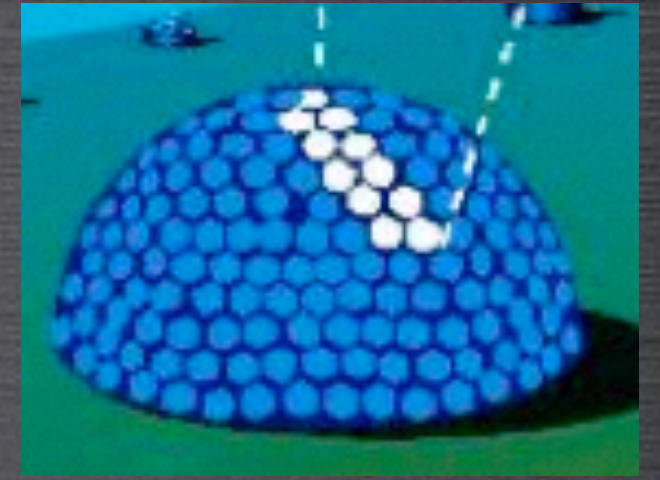
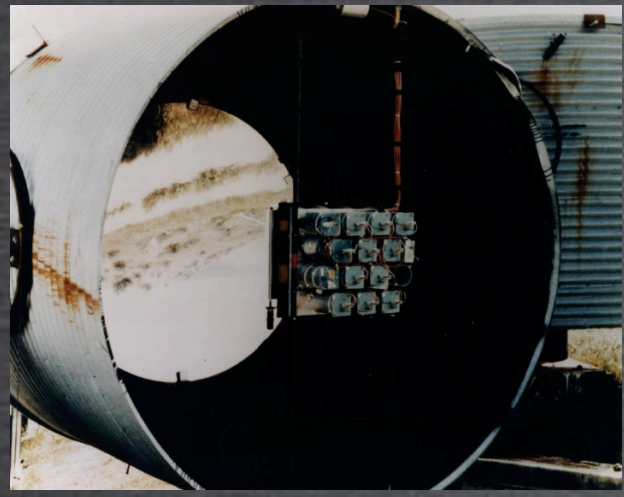
DES SOURCES PROCHES DE LA TERRE ?



1980

PLUS GRAND

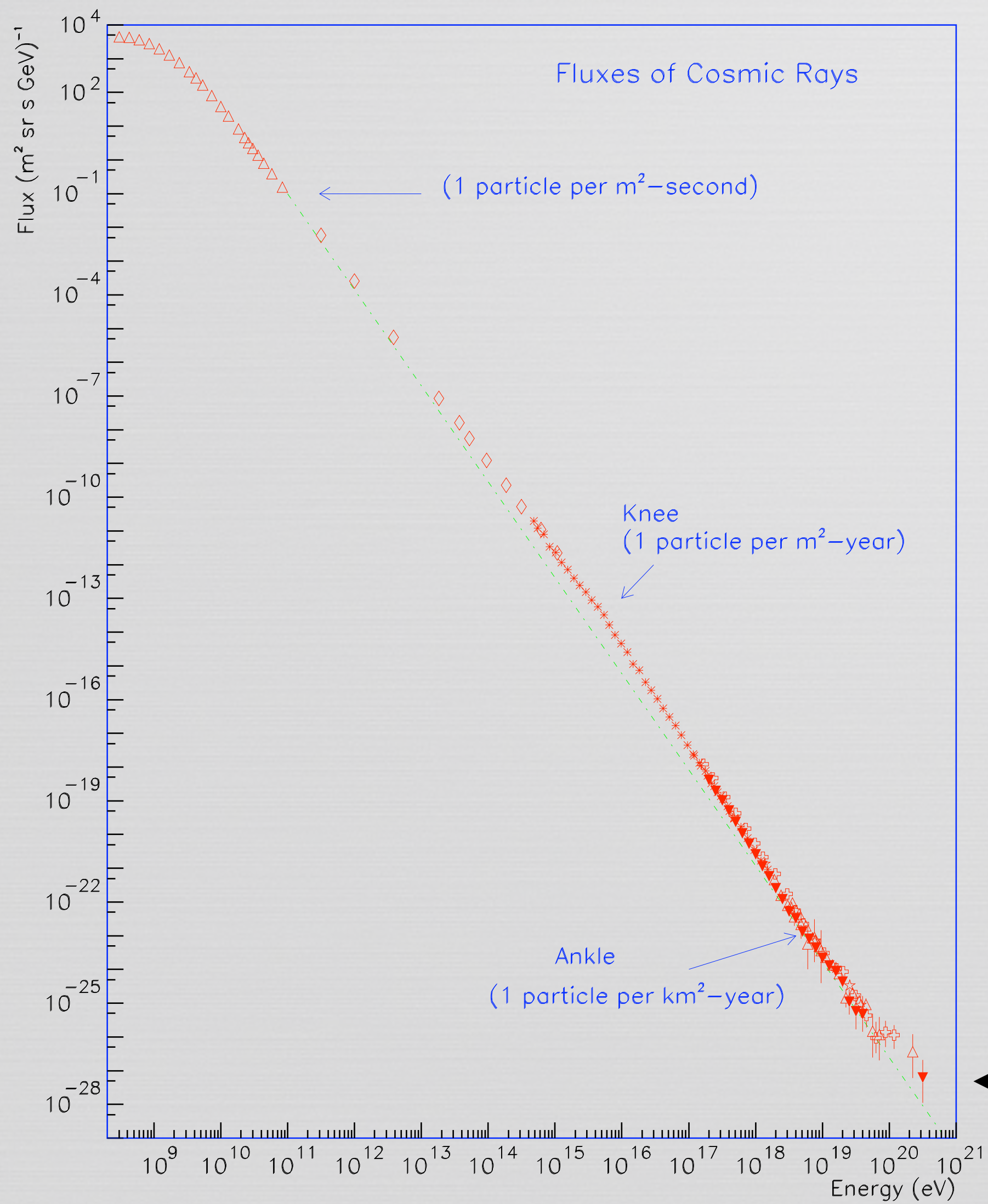
L'OEIL DE MOUCHE



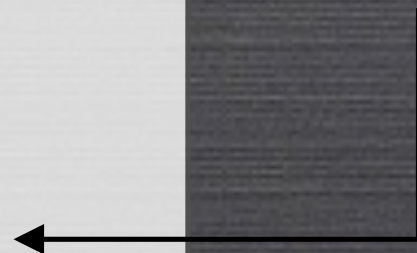
LE RÉSEAU AGASA - JAPON 1990-2001



LE FLUX DES RAYONS COSMIQUES



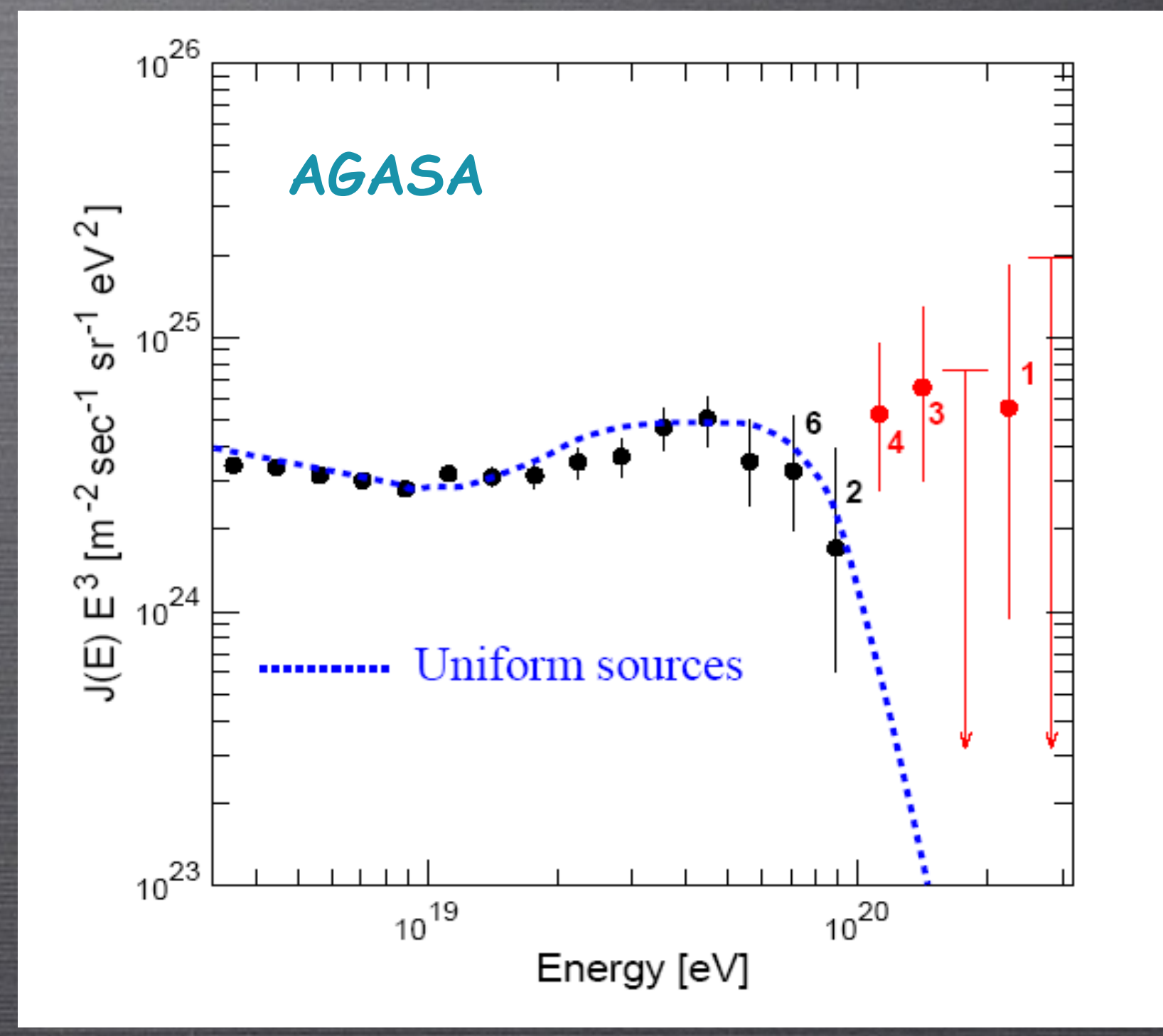
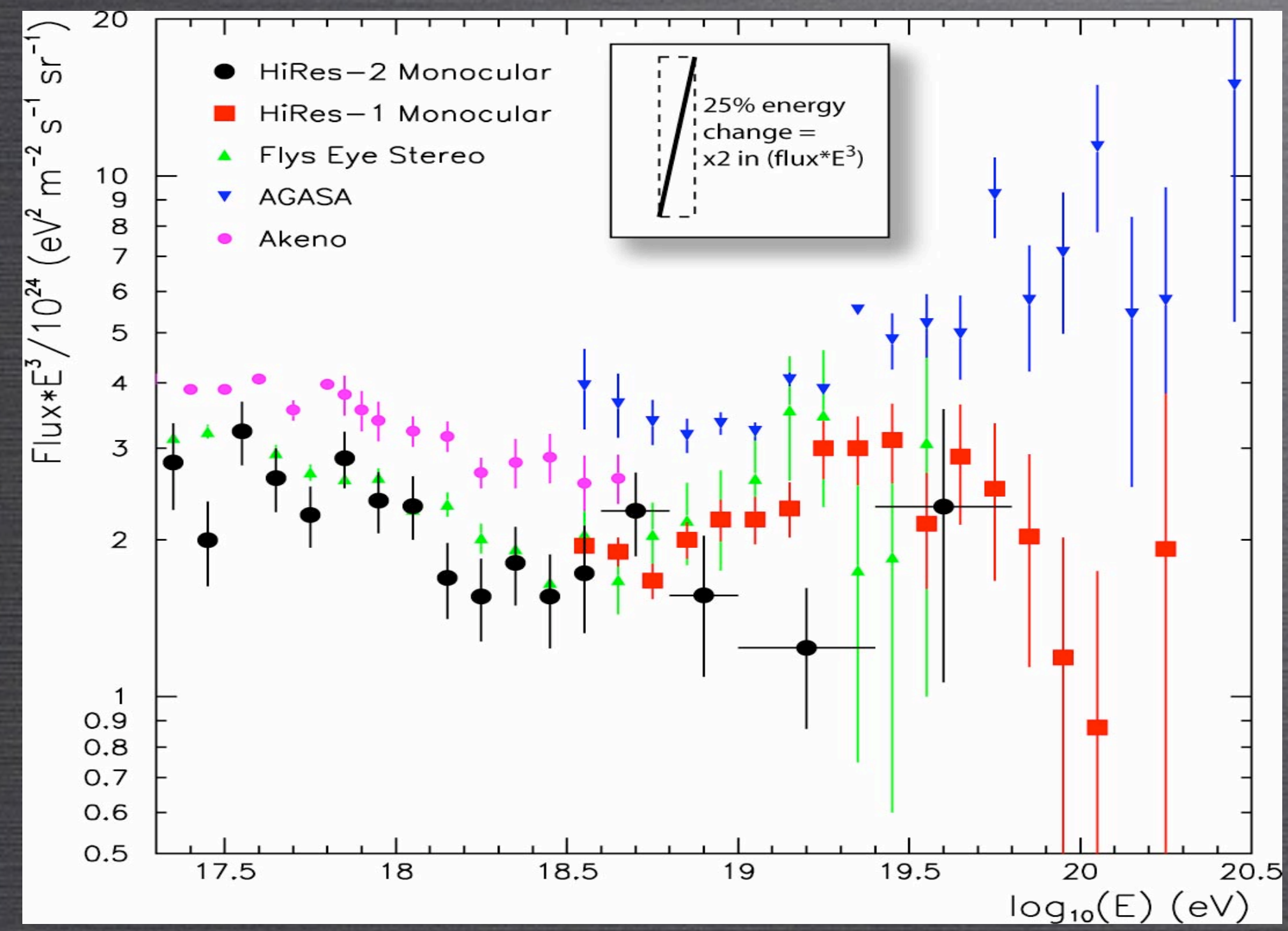
$3 \times 10^{20} \text{ eV} = 50 \text{ joules} = 1 \text{ Tyson } \textcircled{c}$





ANNÉES 1990 : UNE SITUATION CONFUSE

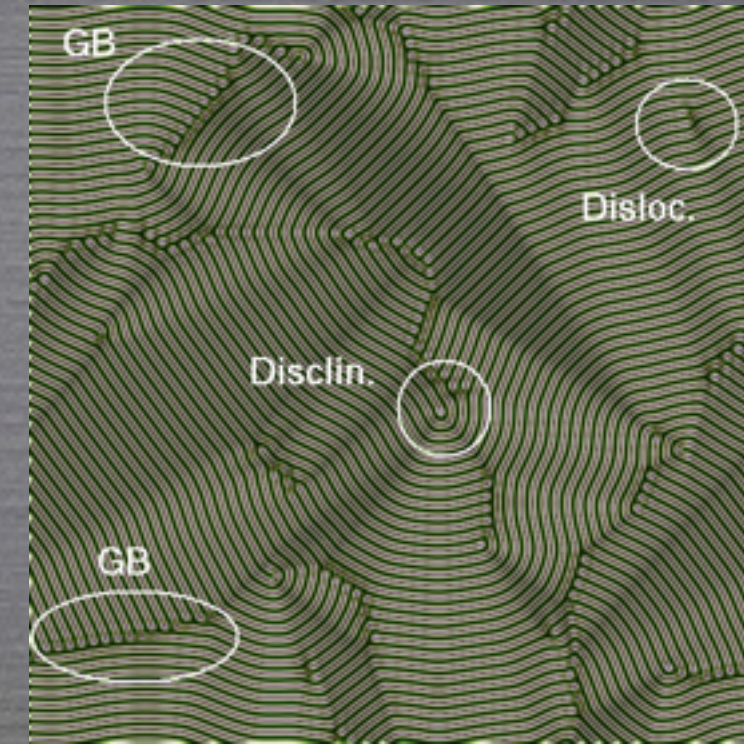
OÙ S'ARRÊTE LE SPECTRE ?



OÙ SONT LES SOURCES ET QUE SONT-ELLES ?

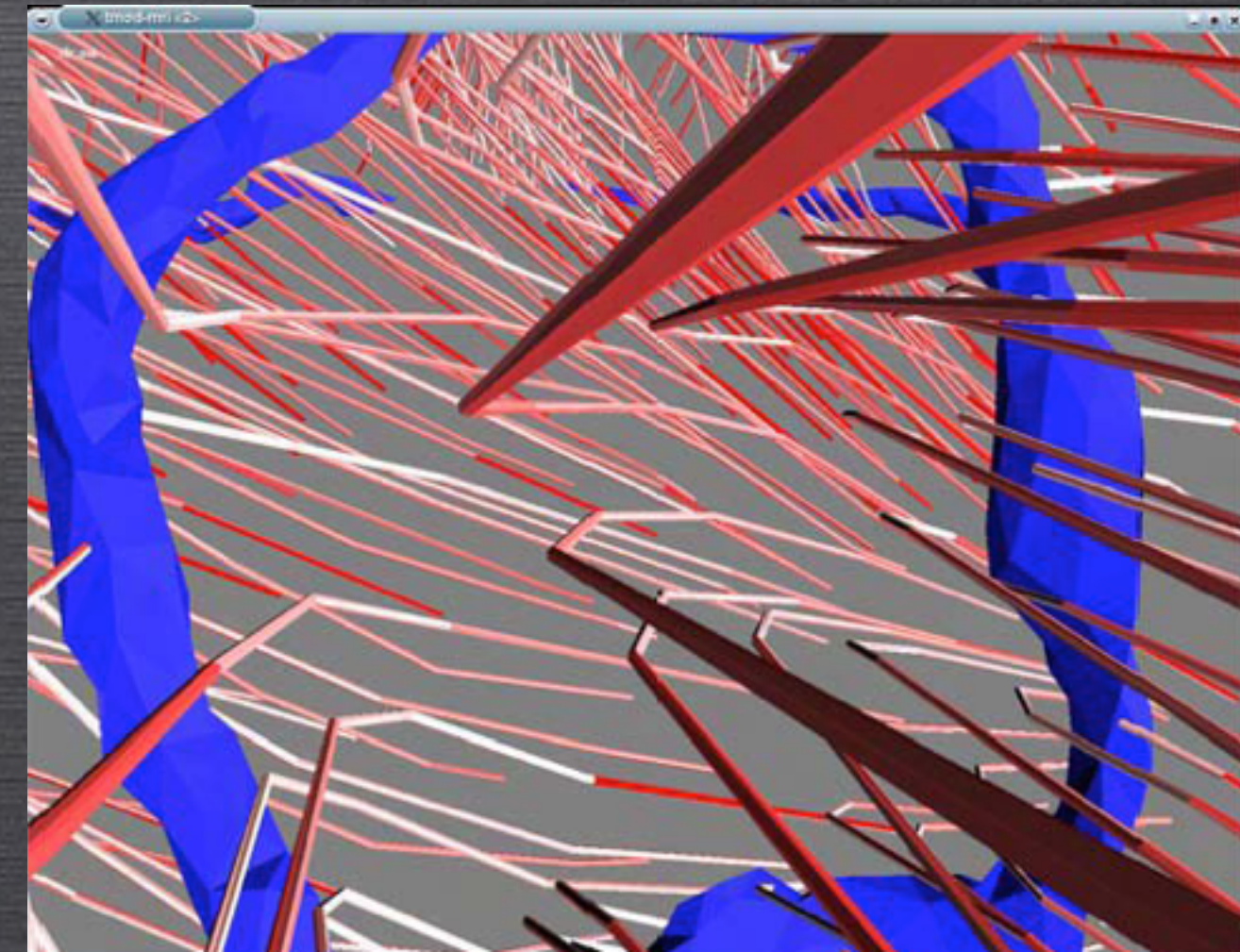


ACCÉLÉRATEURS COSMIQUES
AGN
GALAXIES RADIO
JEUNES ÉTOILES À NEUTRONS
SURSAUTS GAMMA



PRODUCTION DIRECTE
DÉFAUTS TOPOLOGIQUES
RELIQUES (SUPER) MASSIVE DU BIG BANG
LES PHOTONS ET LES NEUTRINOS DOMINENT

LES PROTONS ET LES NOYAUX DOMINENT



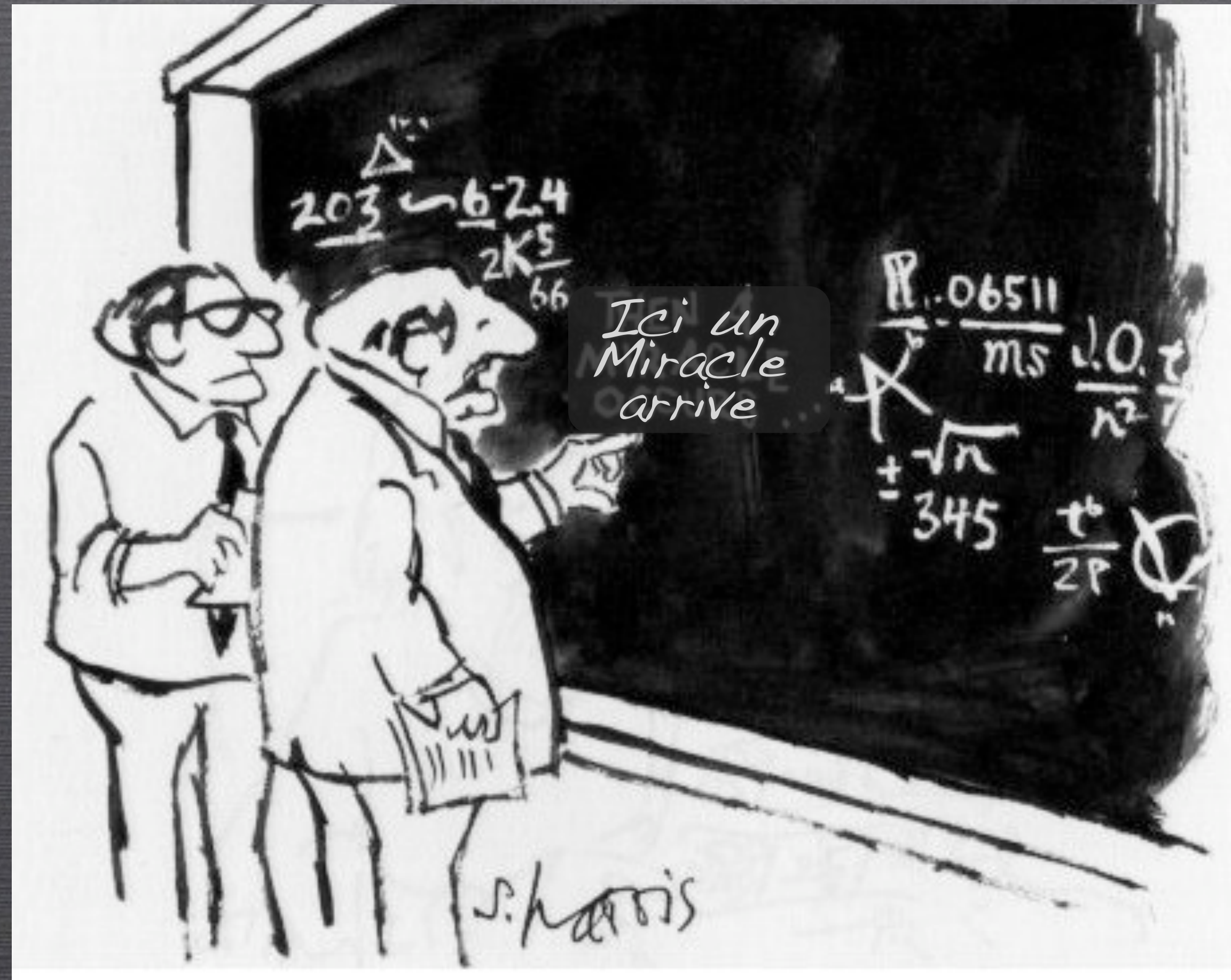
À LA FIN DES ANNÉES 1990

IL Y A DES ÉVÉNEMENTS AU DELÀ DE $5 \times 10^{19} \text{EV}$
(TROP ?)

MAIS

ON LES DIRECTIONS D'ARRIVÉE SUR LE CIEL SONT UNIFORME
(OÙ SONT LES SOURCES ?)

LES EFFORTS THÉORIQUES SONT NOMBREUX
MAIS PEUT CONVAINCANTS...



“JE PENSE QUE VOUS DEVRIEZ ÊTRE PLUS EXPLICITE SUR LA 2IÈME ÉTAPE”

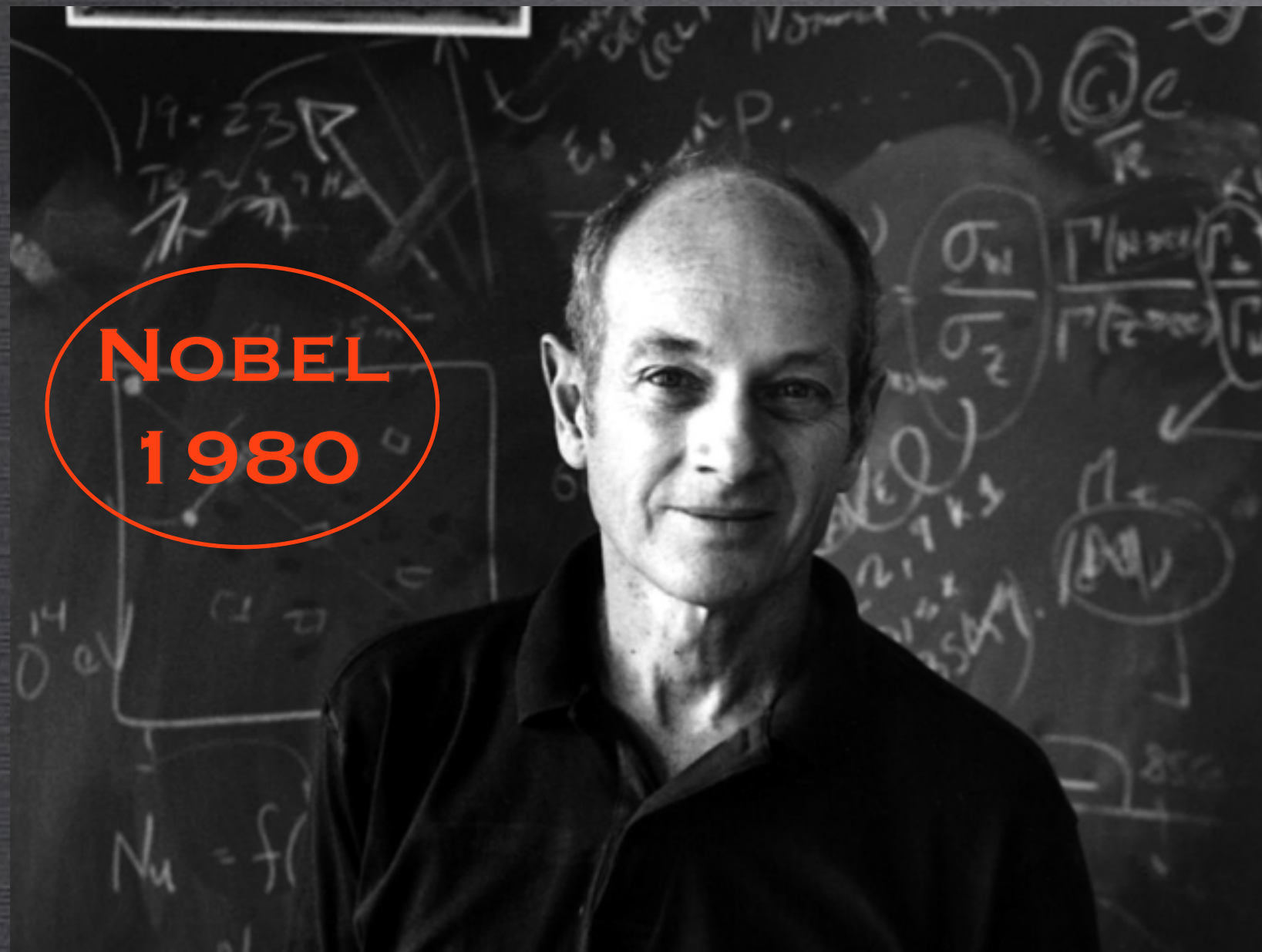
From Sidney Harris

1990

ENCORE

PLUS

GRAND

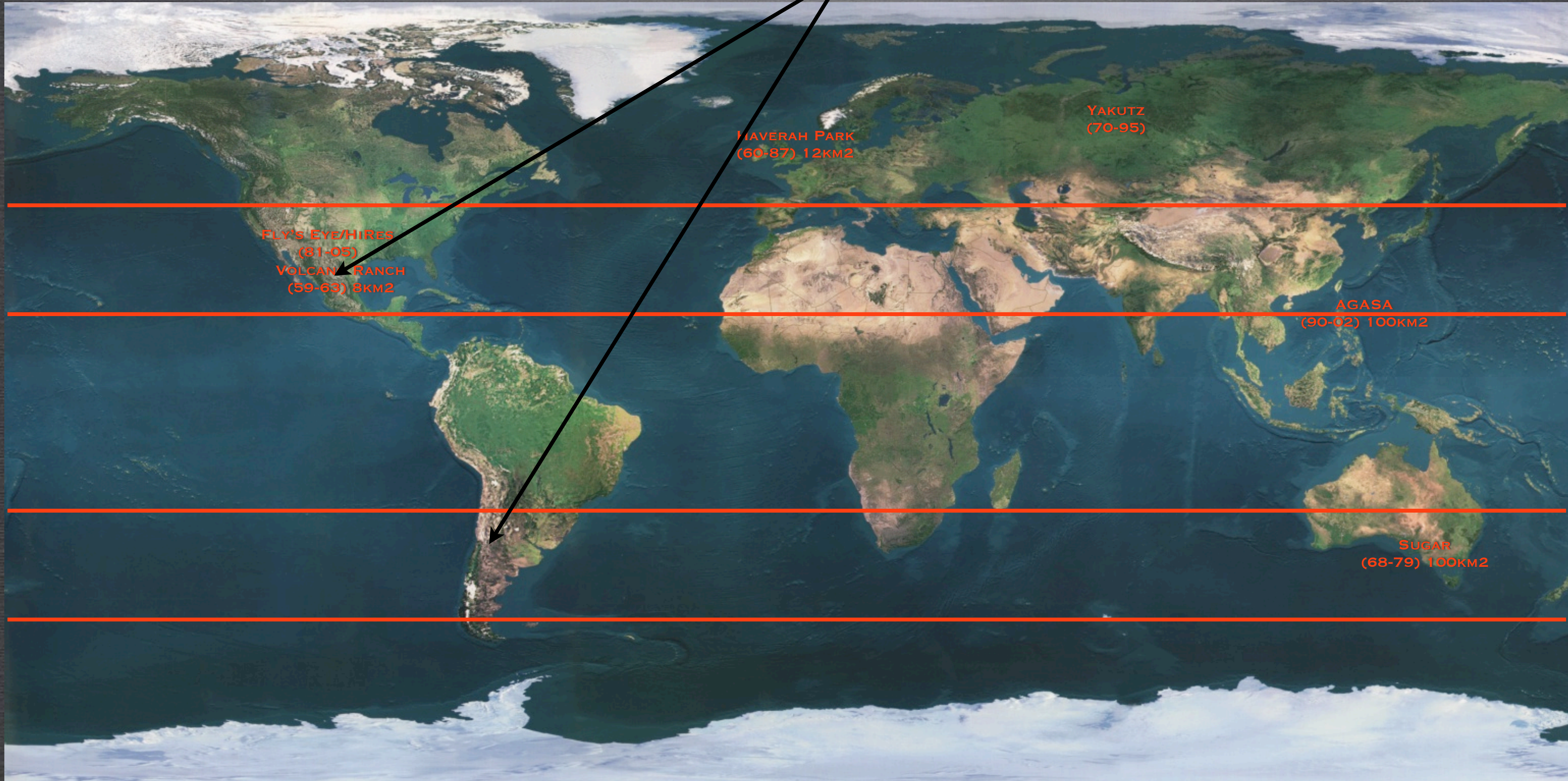


JIM CRONIN PROPOSE UN DÉTECTEUR DE 5000 KM² :
C'EST LA NAISSANCE DU PROJET AUGER

PROBLÈMES :

- ✦ PAS D'ARGENT POUR FAIRE QUOI QUE CE SOIT
- ✦ IL FAUT CONVAINCRE LA COMMUNAUTÉ QUE CELA VAUT LA PEINE ET QU'ON SAURA LE FAIRE
- ✦ IL FAUT TROUVER UN SITE
- ✦ MONTER UNE COLLABORATION ET RÉUNIR 100M\$
- ✦ VA-T-ON MESURER QUELQUE CHOSE ?
- ✦ EST-CE QUE 5000 KM² SUFFIRONT ?

2 SITES SÉLECTIONNÉS 1995/1996

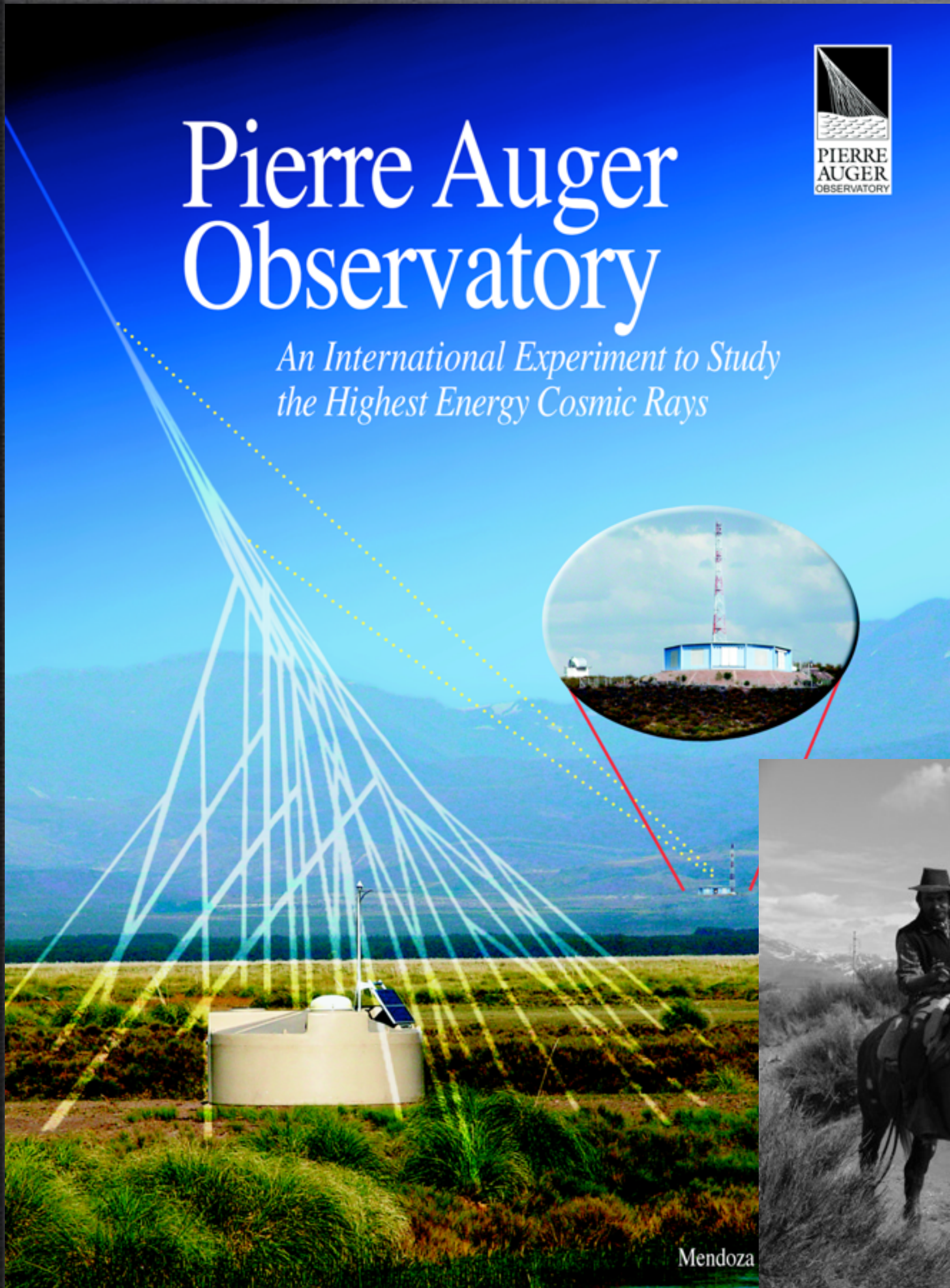


2 CHERCHEURS [AMÉRICAIN/FRANÇAIS] ONT EUT LE MEILLEUR TRAVAIL DU MONDE :
VOYAGER SUR TOUTE LA PLANÈTE POUR RENCONTRER LES GENS ET ÉVALUER LES SITES. 20 SITES VISITÉS DANS 7 PAYS.

L'OBSERVATOIRE PIERRE AUGER

Pierre Auger Observatory

*An International Experiment to Study
the Highest Energy Cosmic Rays*



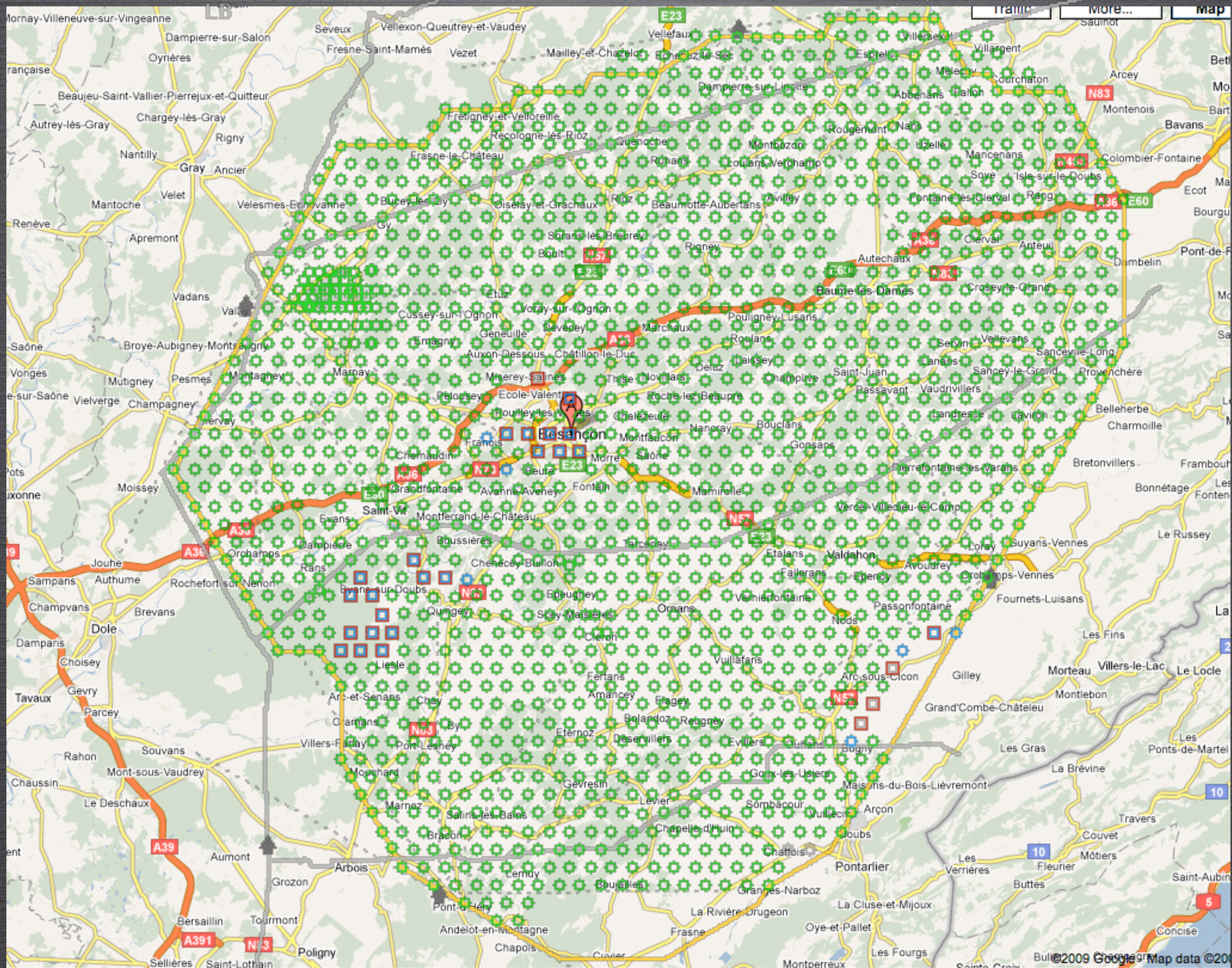
Mendoza

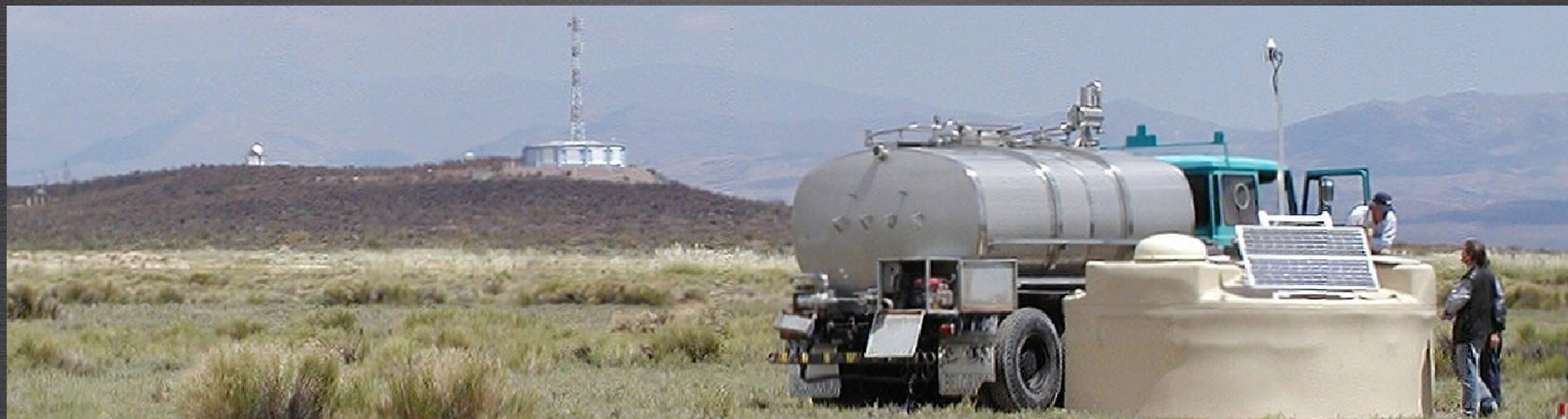
UN DÉTECTEUR HYBRIDE

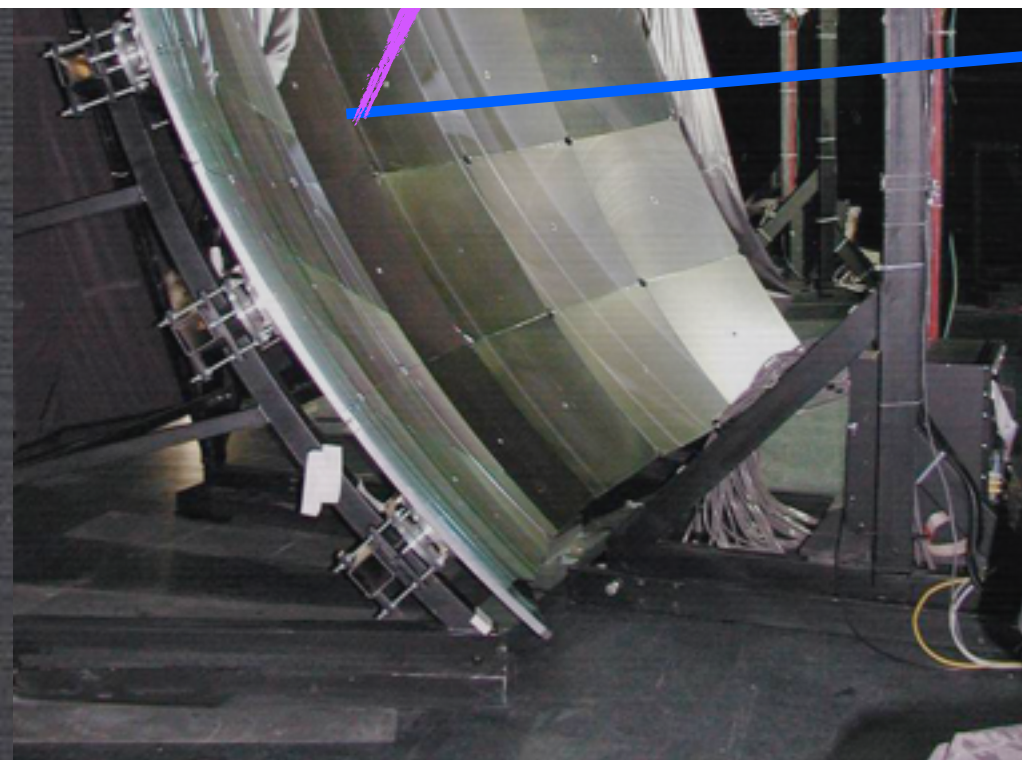
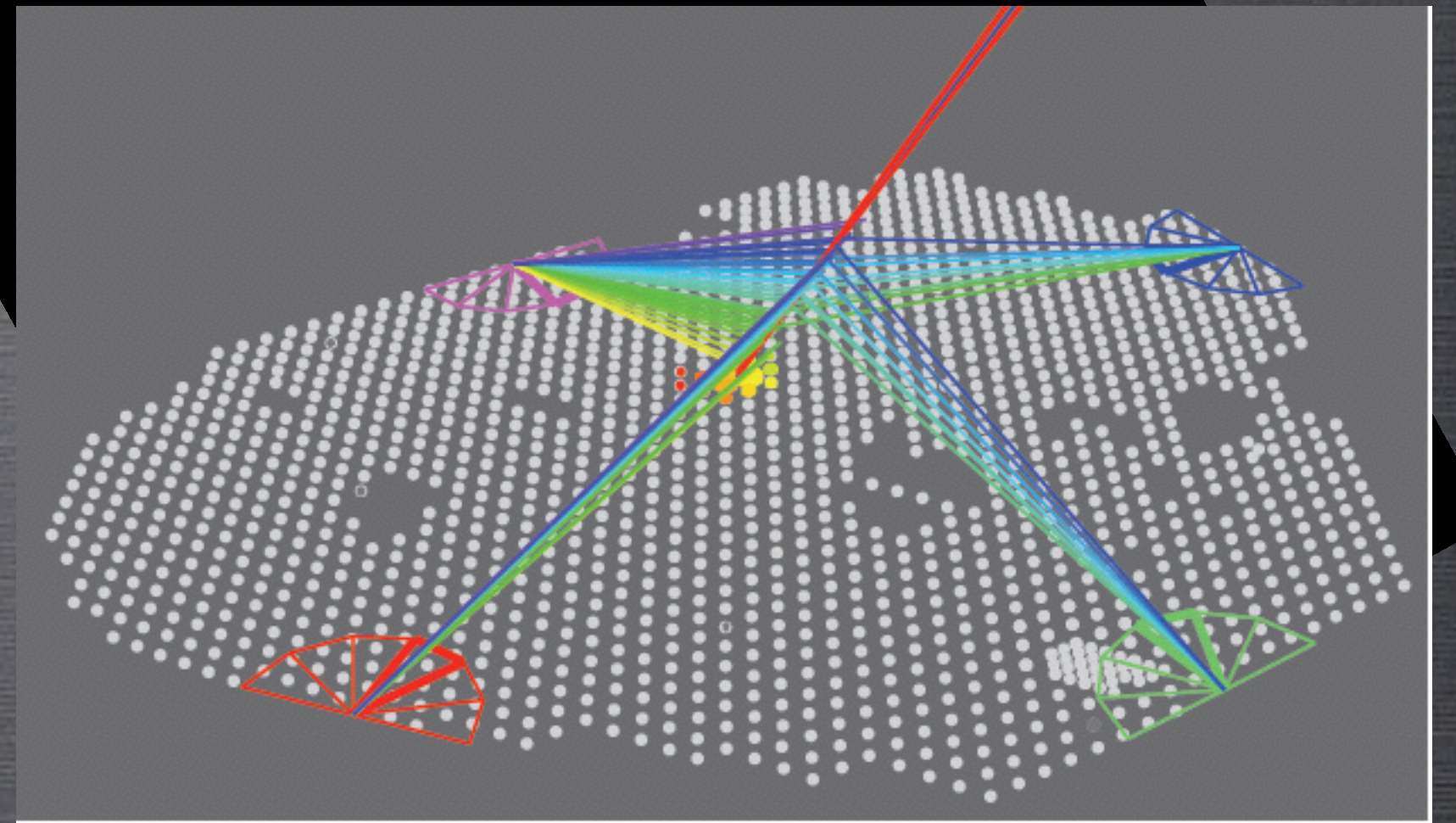
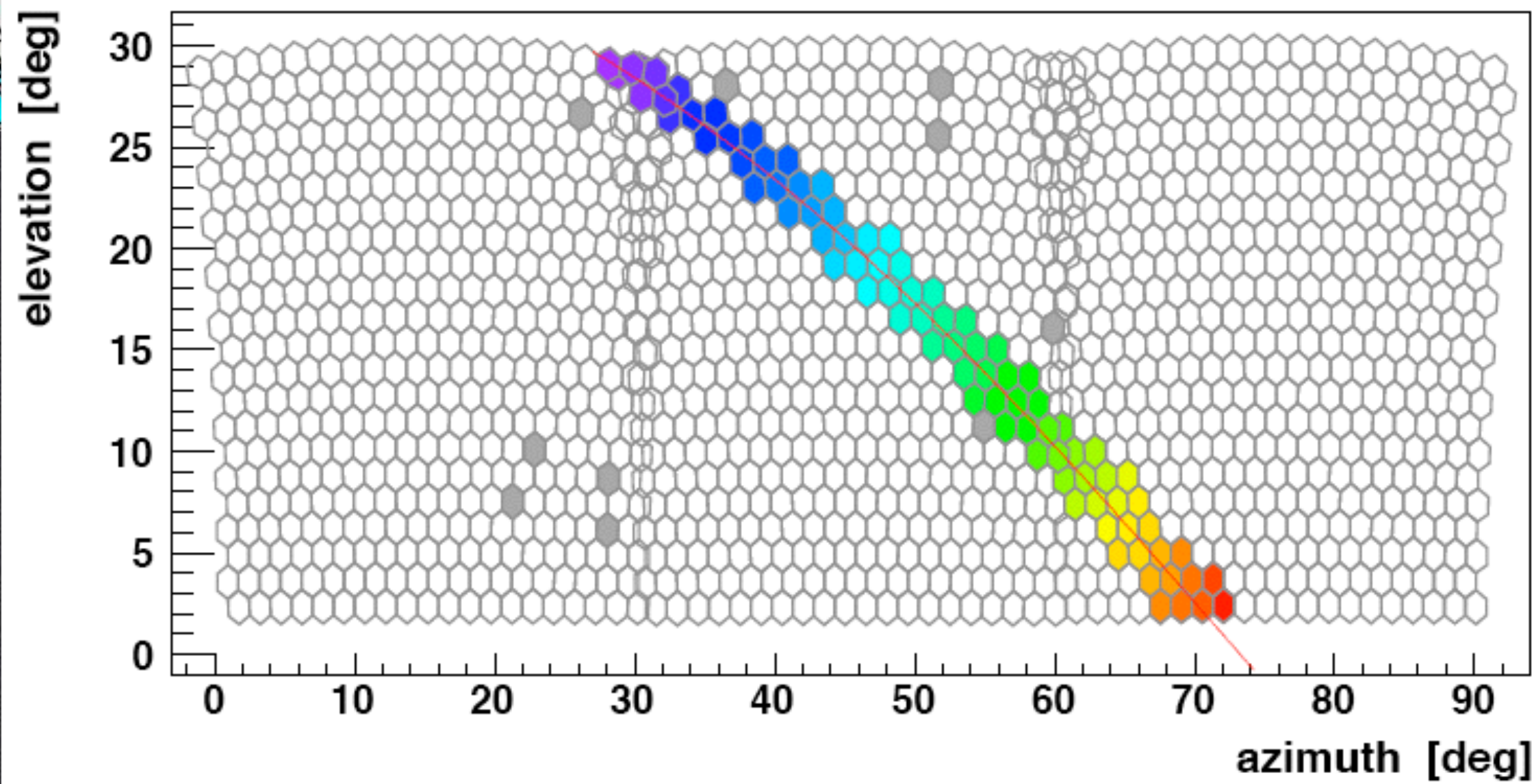
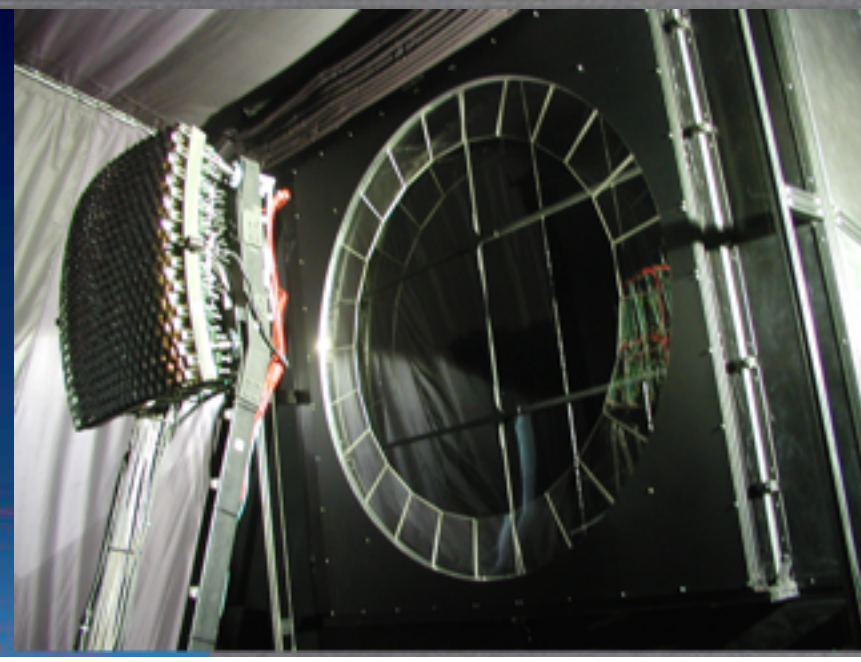
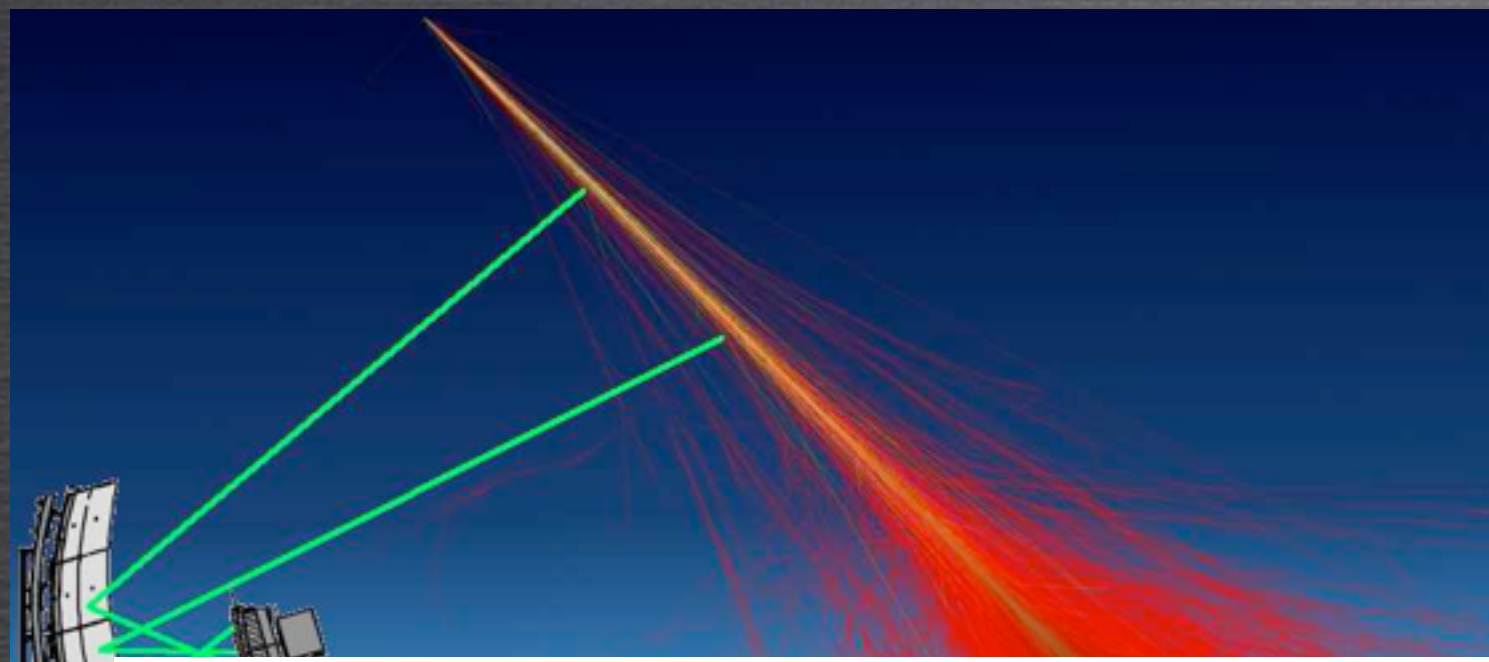
RÉSEAU DE SURFACE :
1 600 CUVES CHÉRENKOV RÉPARTIES
TOUS LES 1,5 KM SUR UNE SURFACE
DE 3 000 KM²

DÉTECTEUR DE FLUORESCENCE :
4 SITE DE 6 TÉLESCOPES À
FLUORESCENCE POUR REGARDER
L'ATMOSPHÈRE AU DESSUS DU
RÉSEAU DE SURFACE

INTER CALIBRAGE / PRÉCISION /
STABILITÉ & EFFICACITÉ

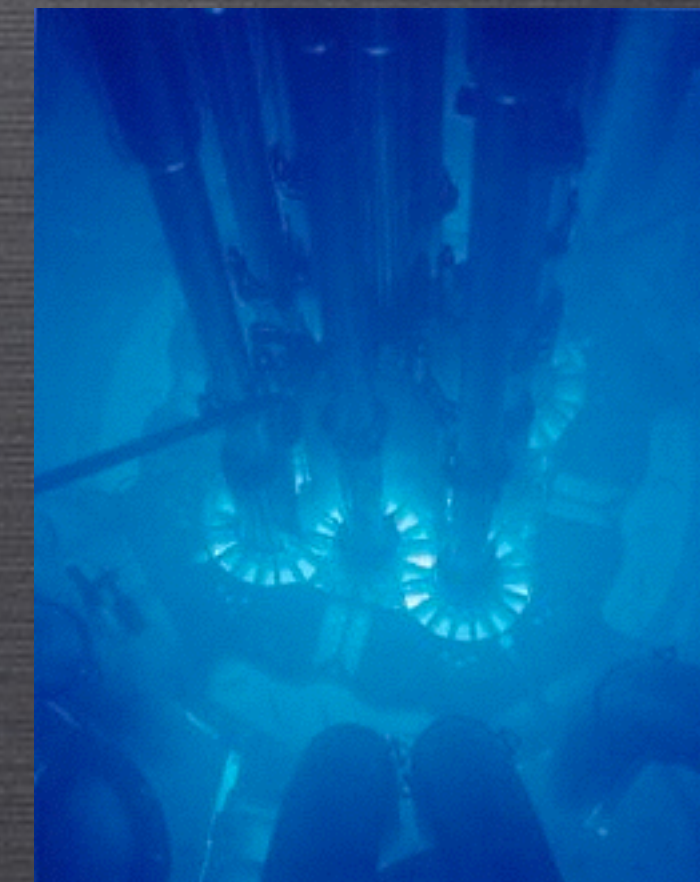
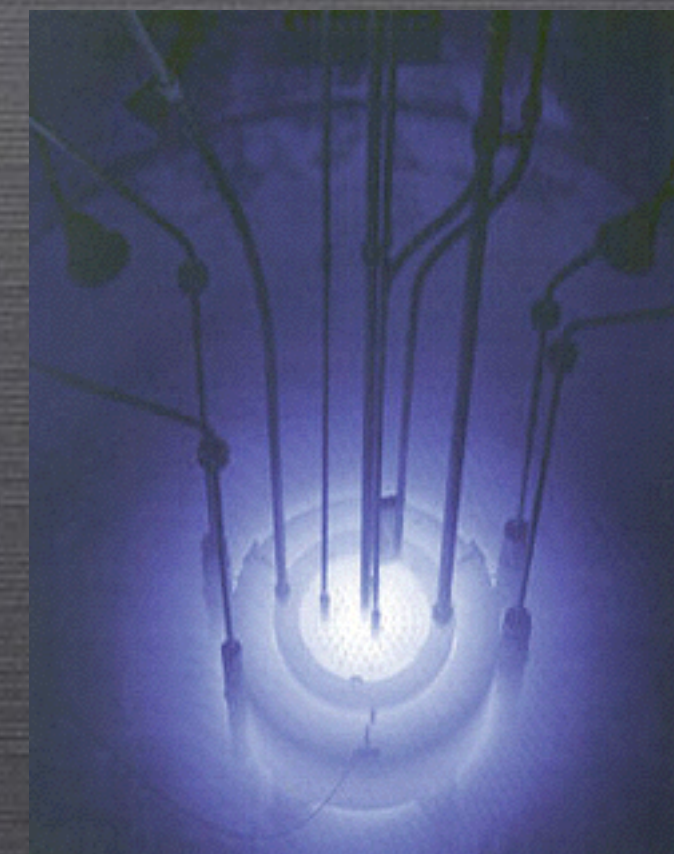
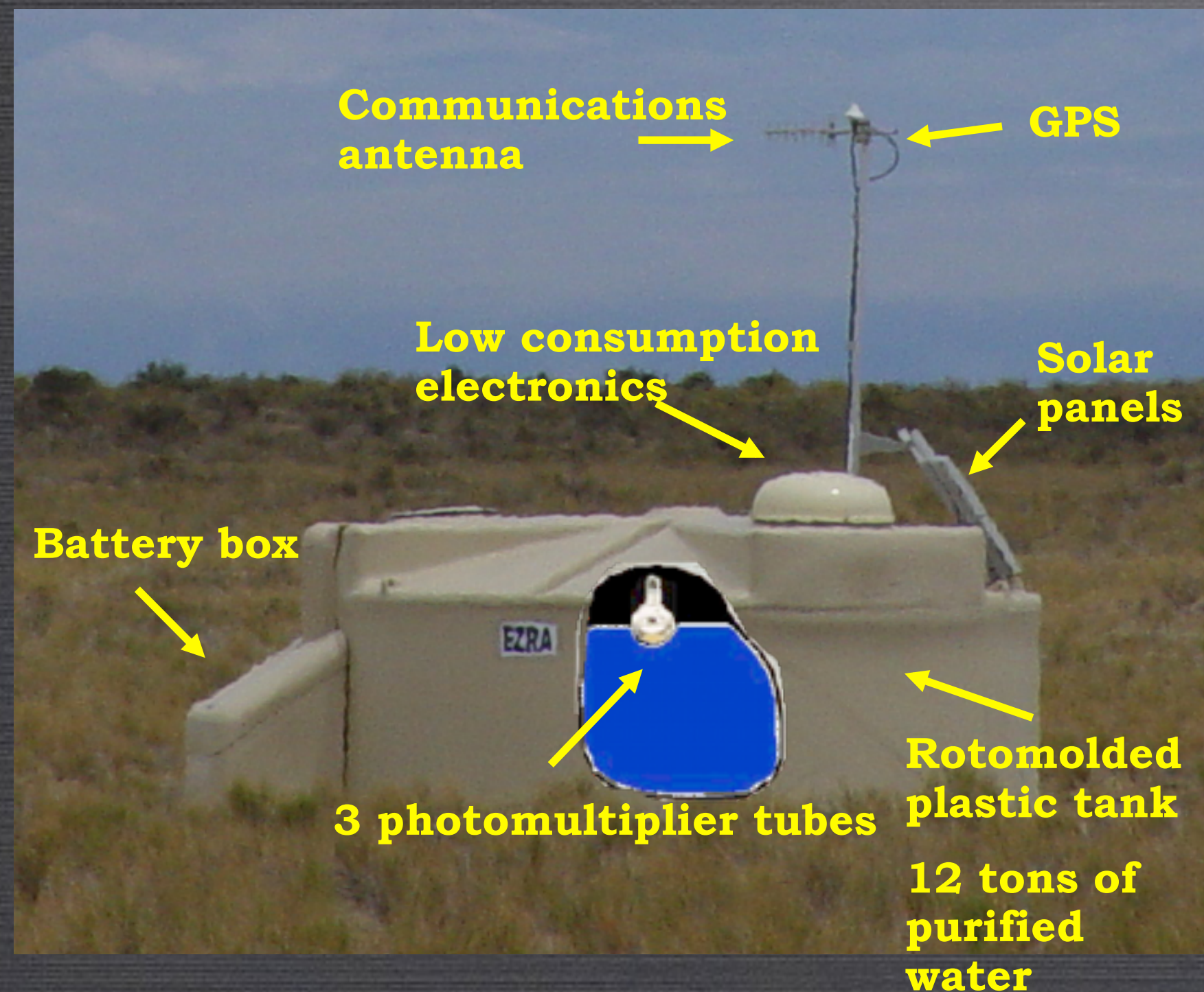
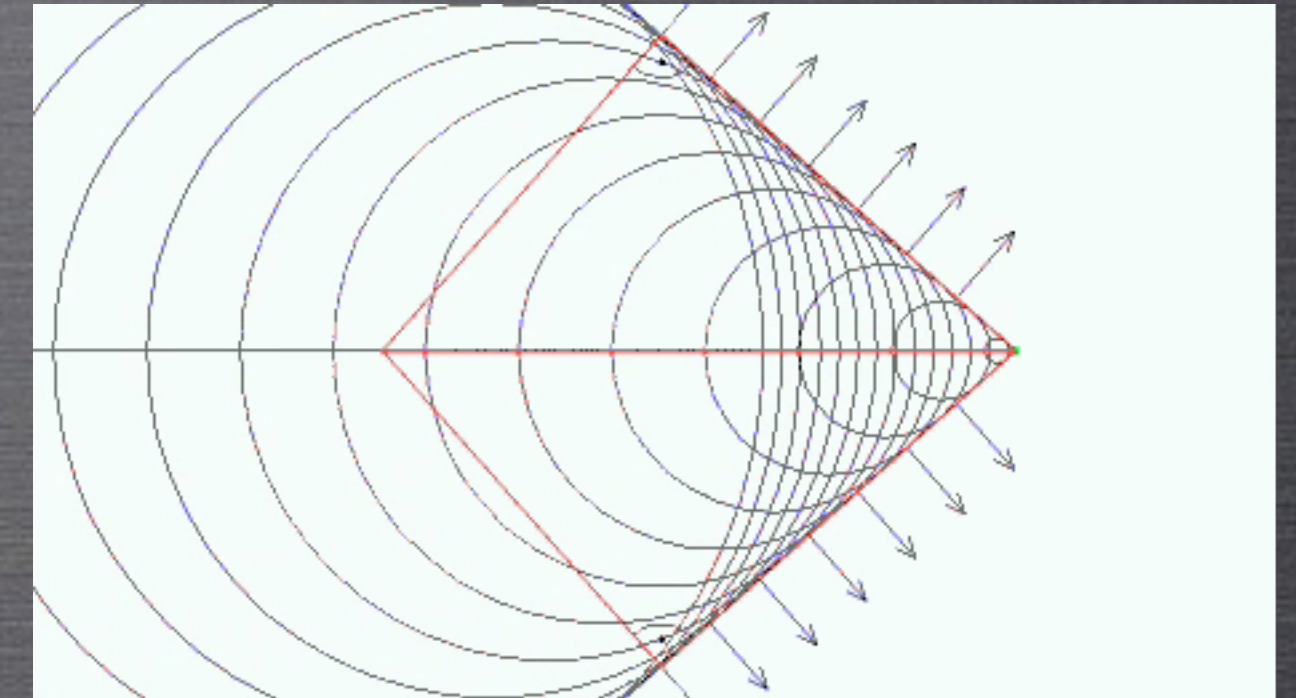
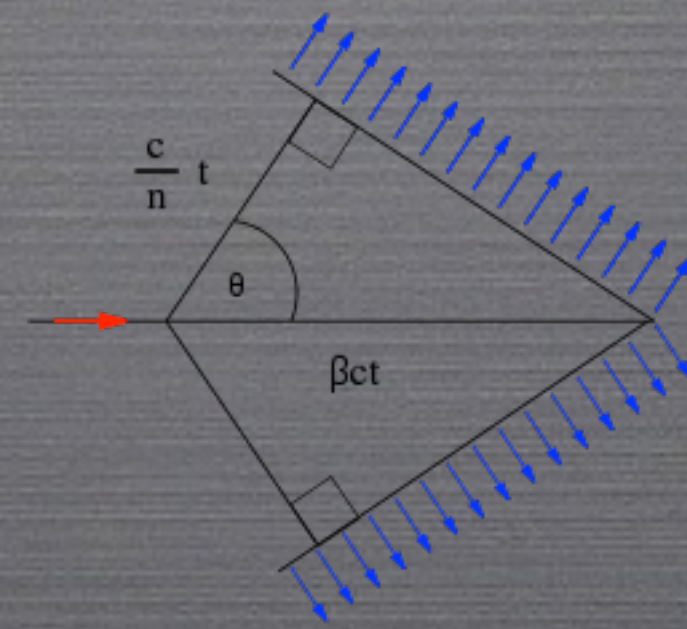
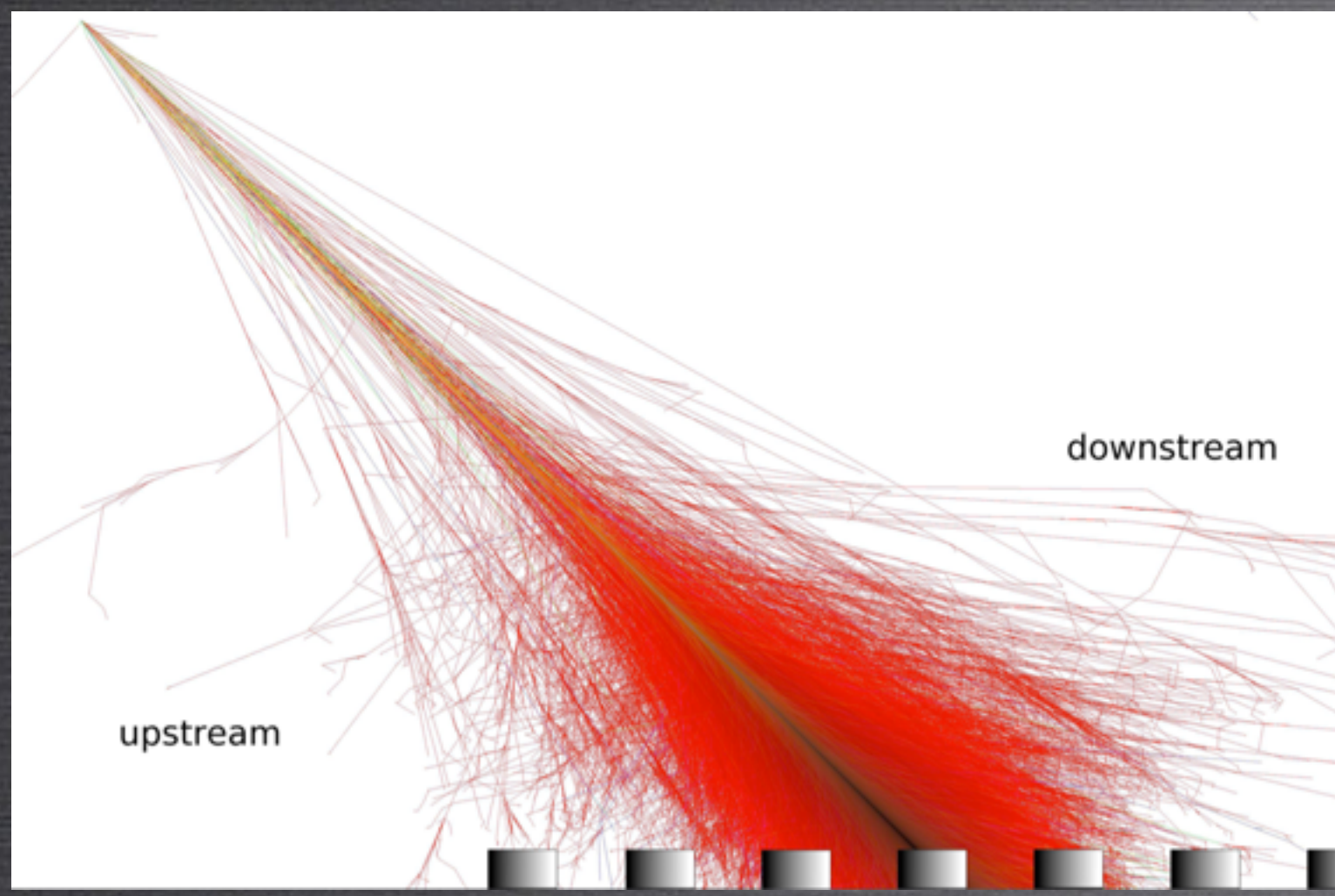






UN DÉTECTEUR DE FLUORESCENCE

UN DÉTECTEUR DE SURFACE & L'EFFET CHERENKOV

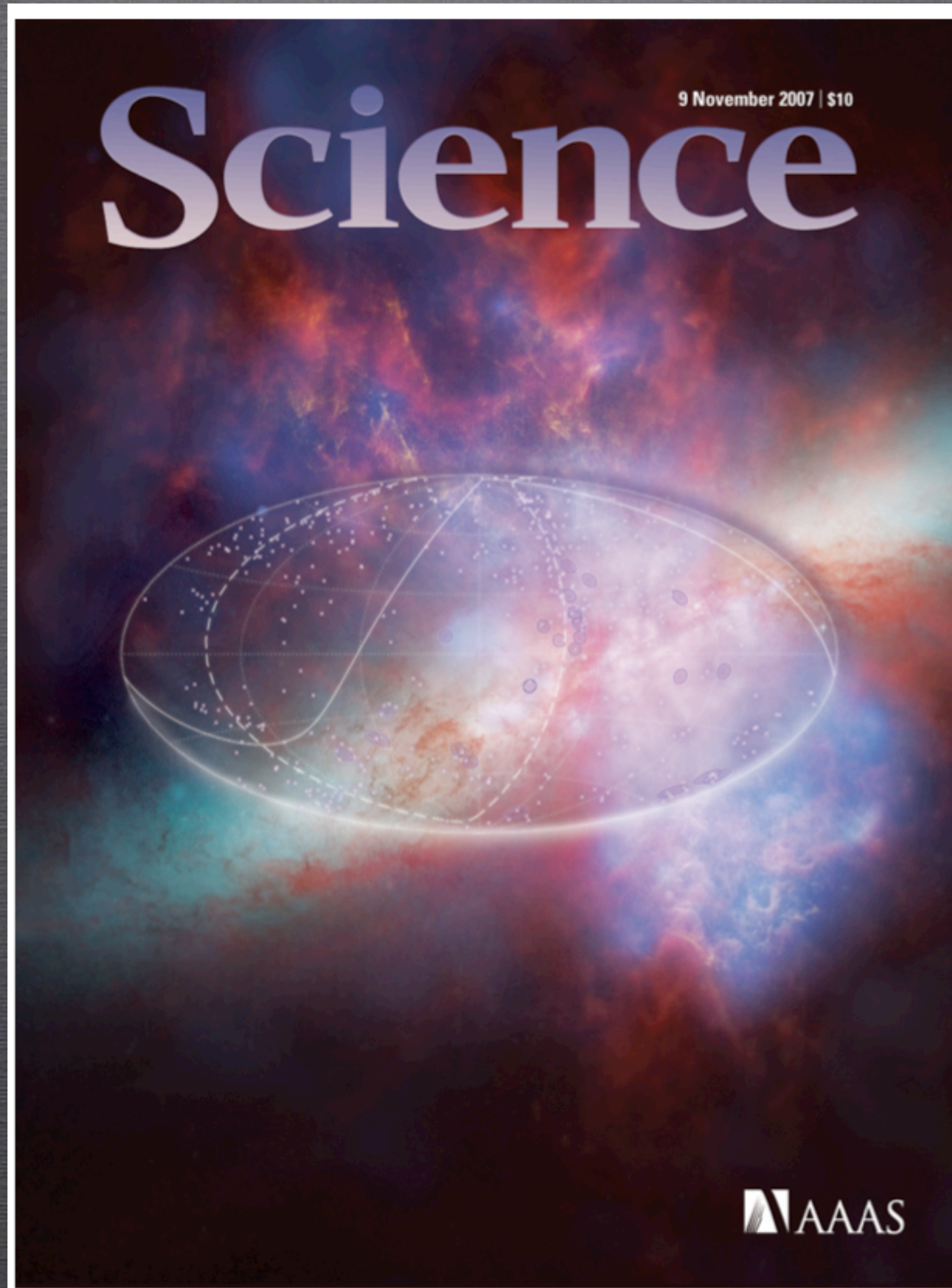




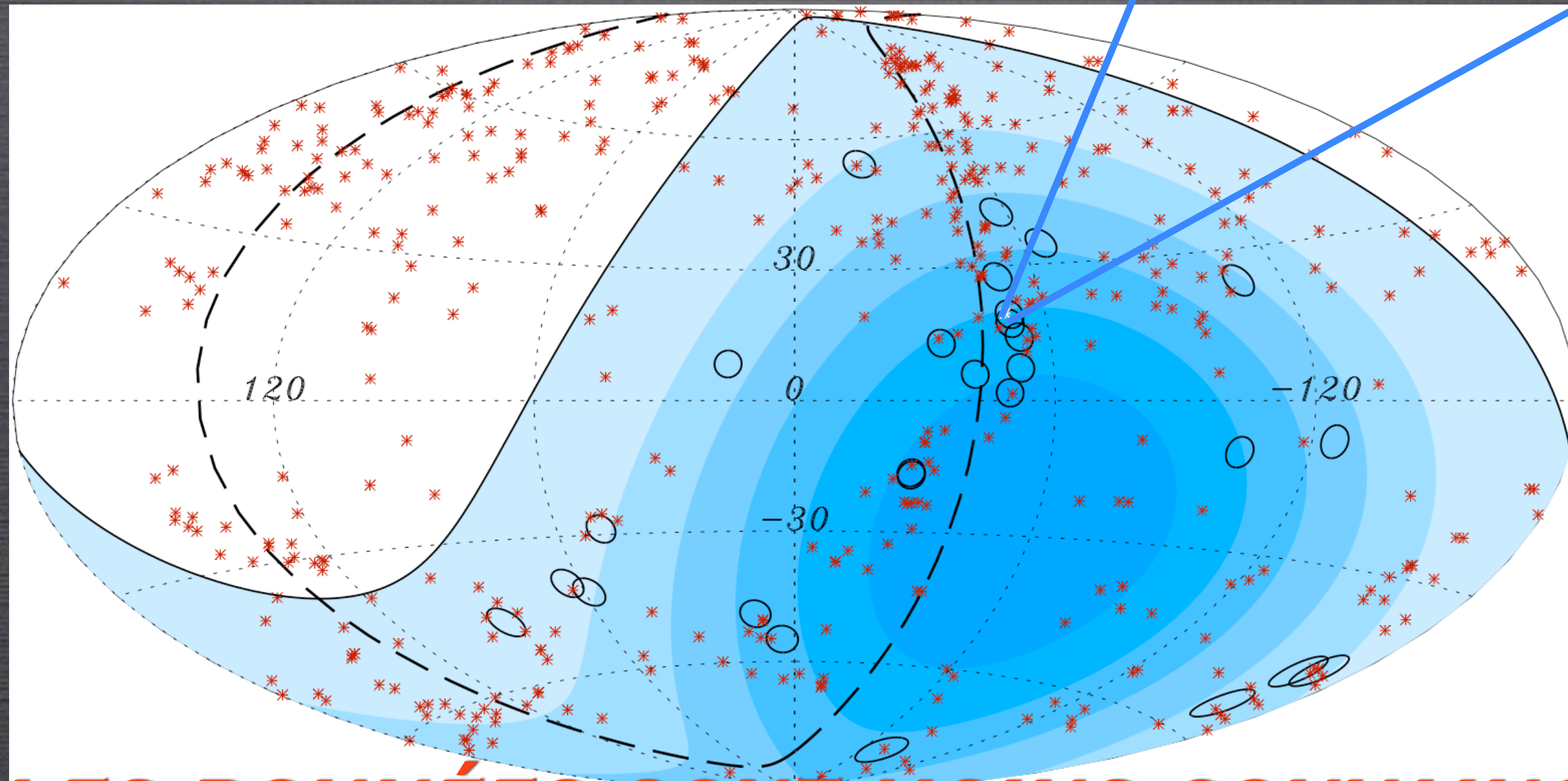
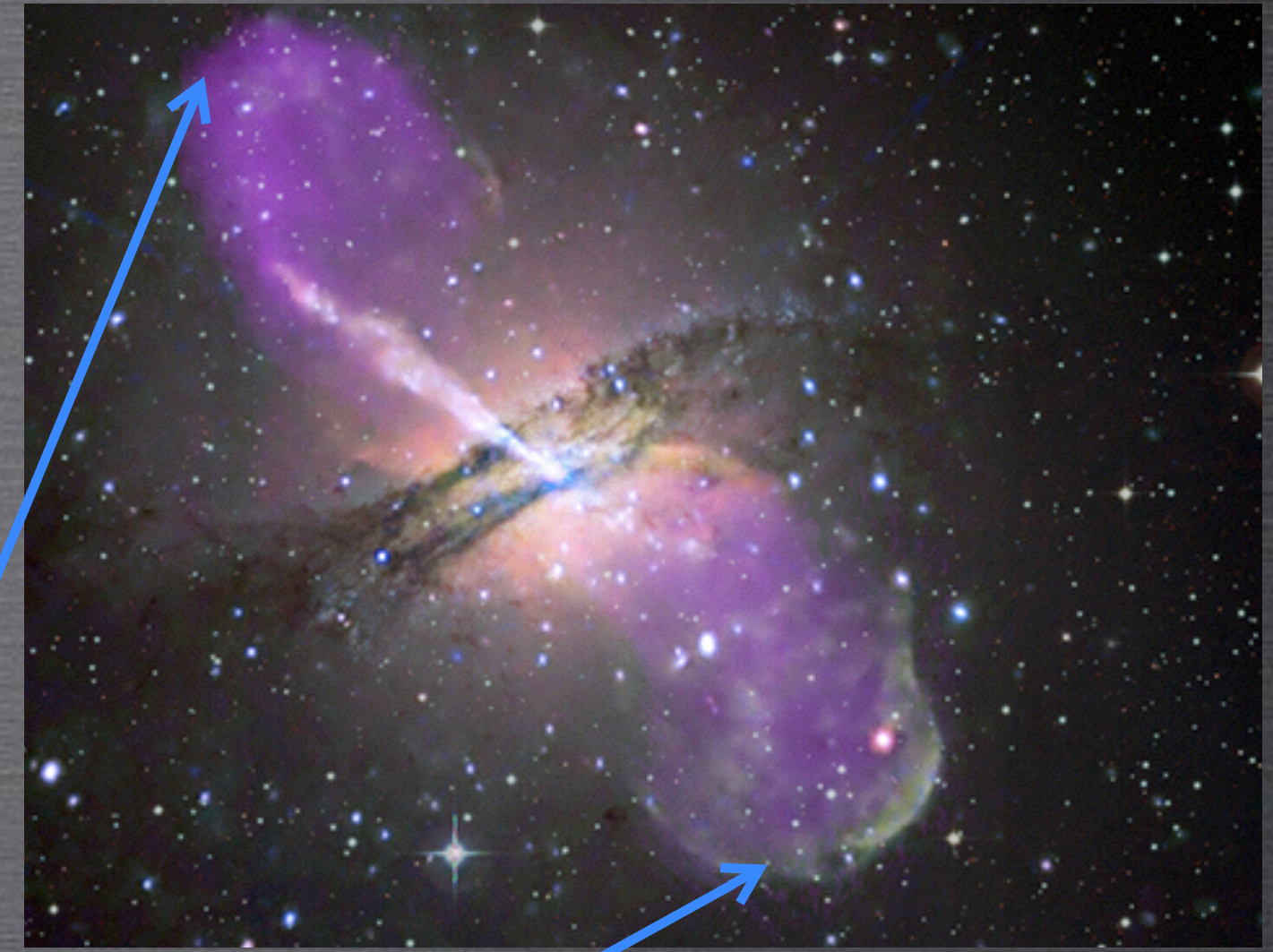
FAUT PAS RÊVER - ARNAUD BLIN - FR3 AUTOMNE 2008

NOVEMBRE
2007

LES
SOURCES
APPARAISSENT-
-ELLES ENFIN ?

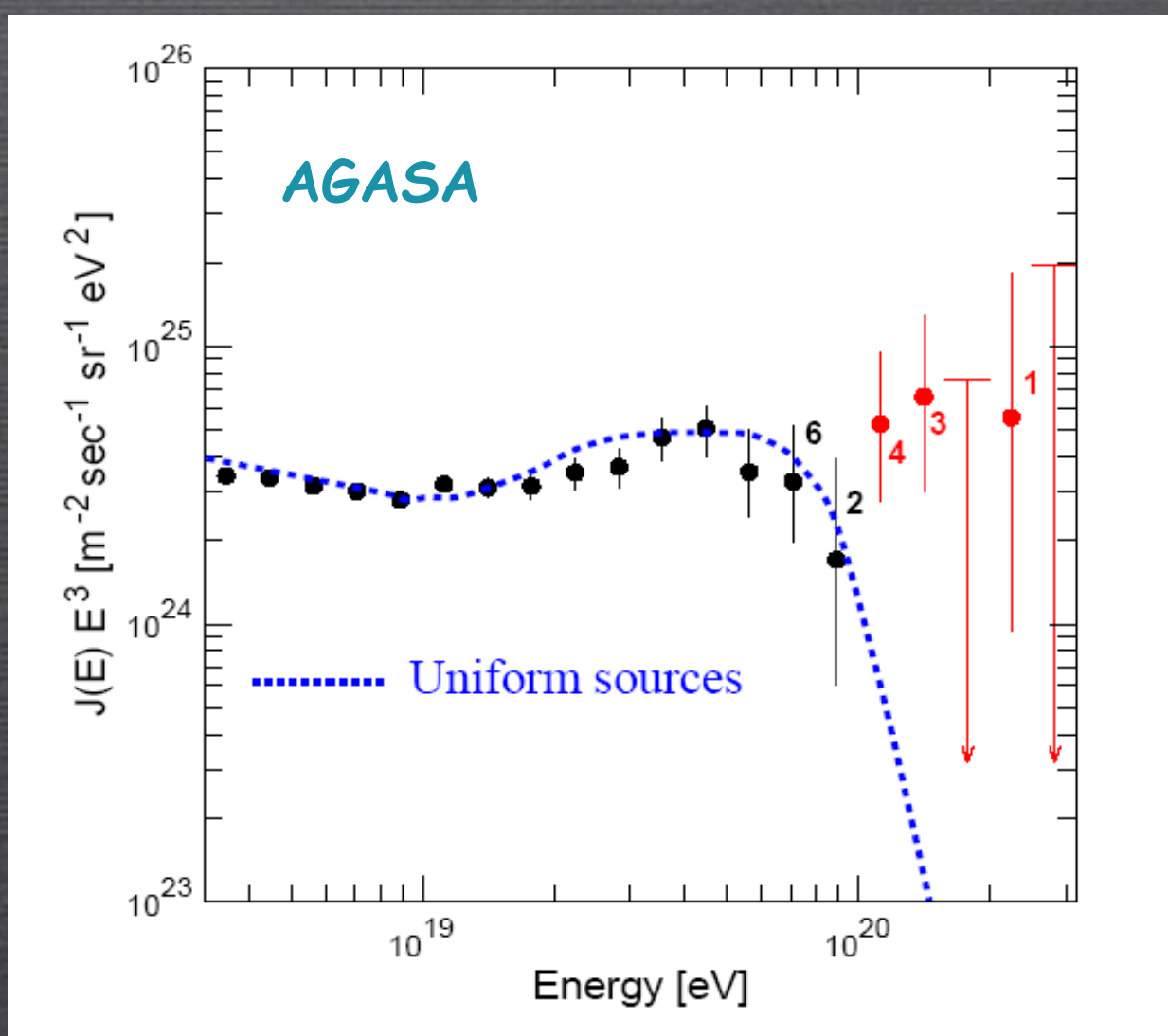
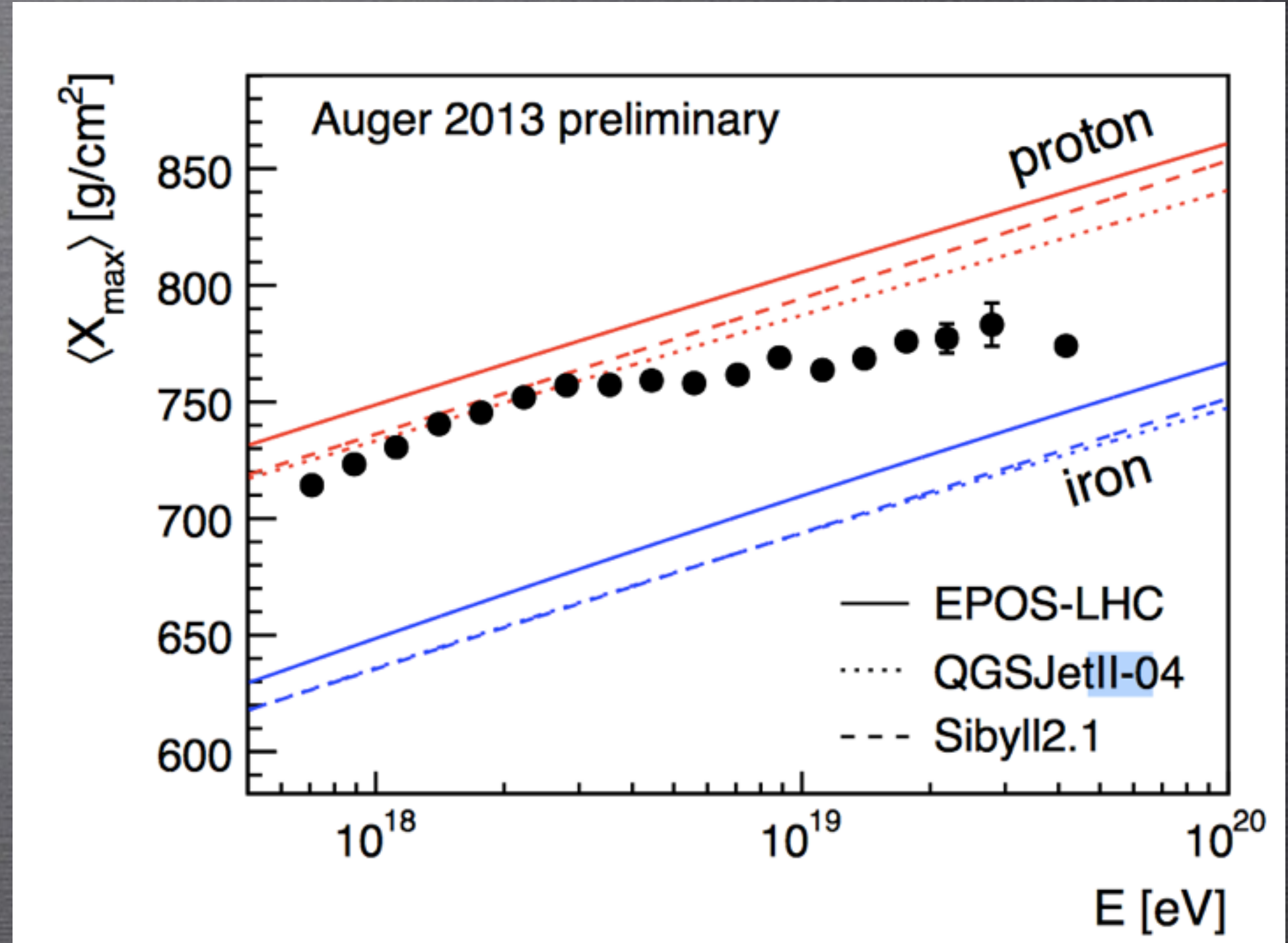
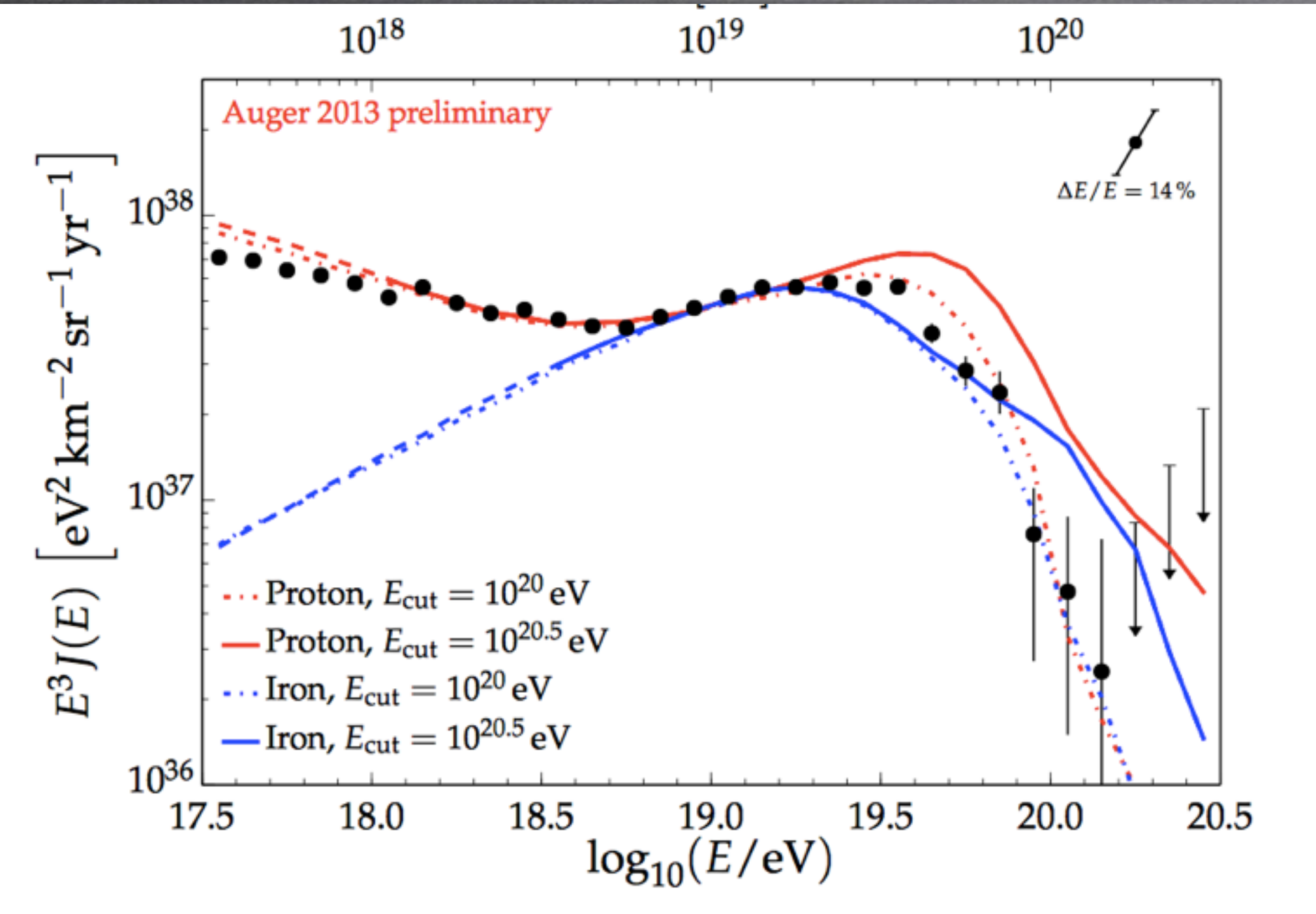


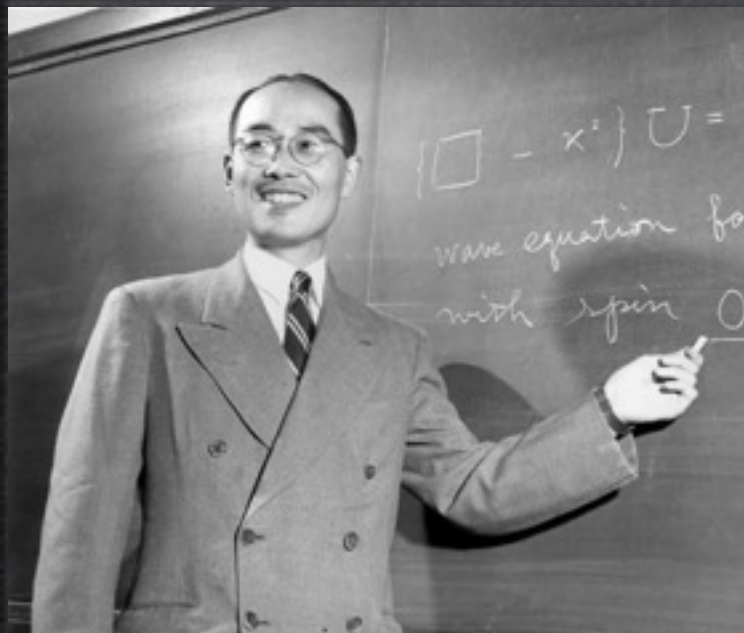
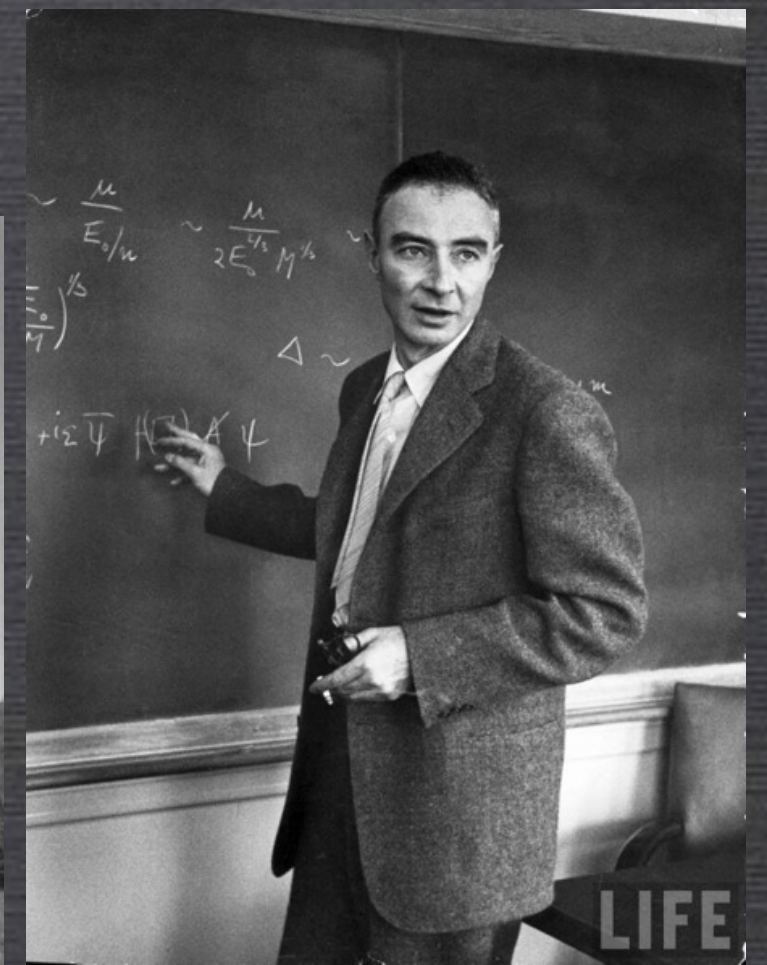
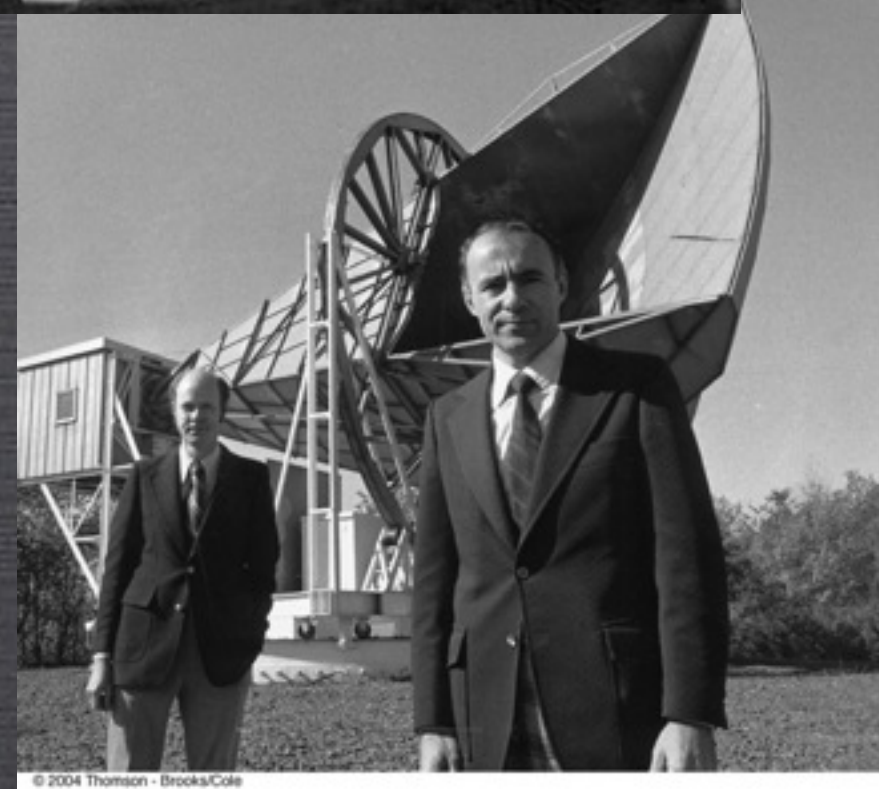
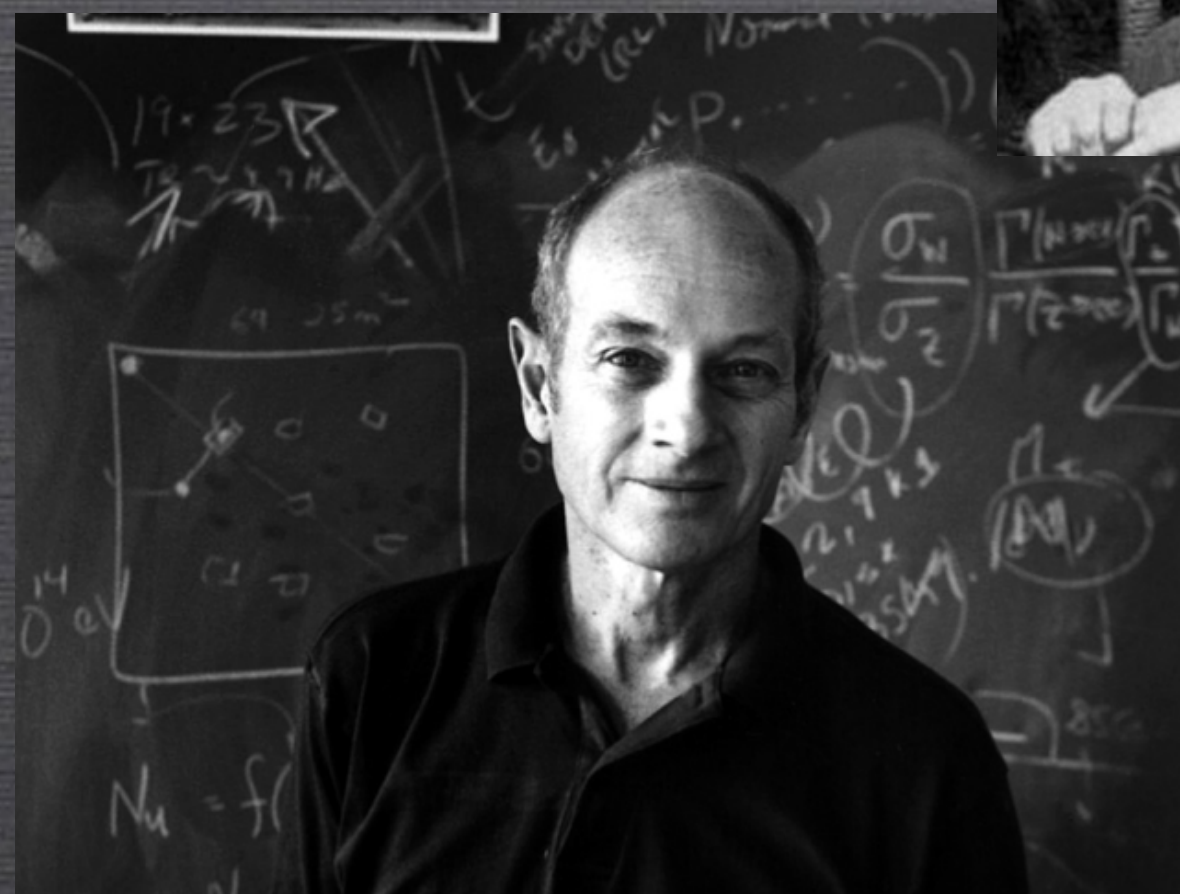
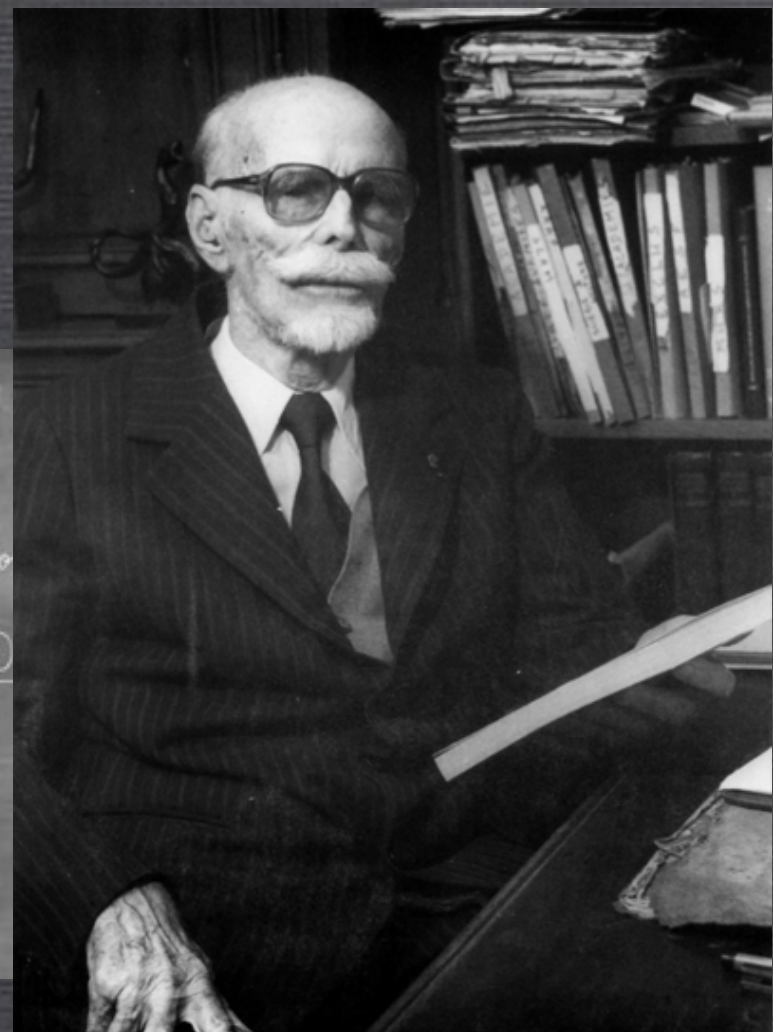
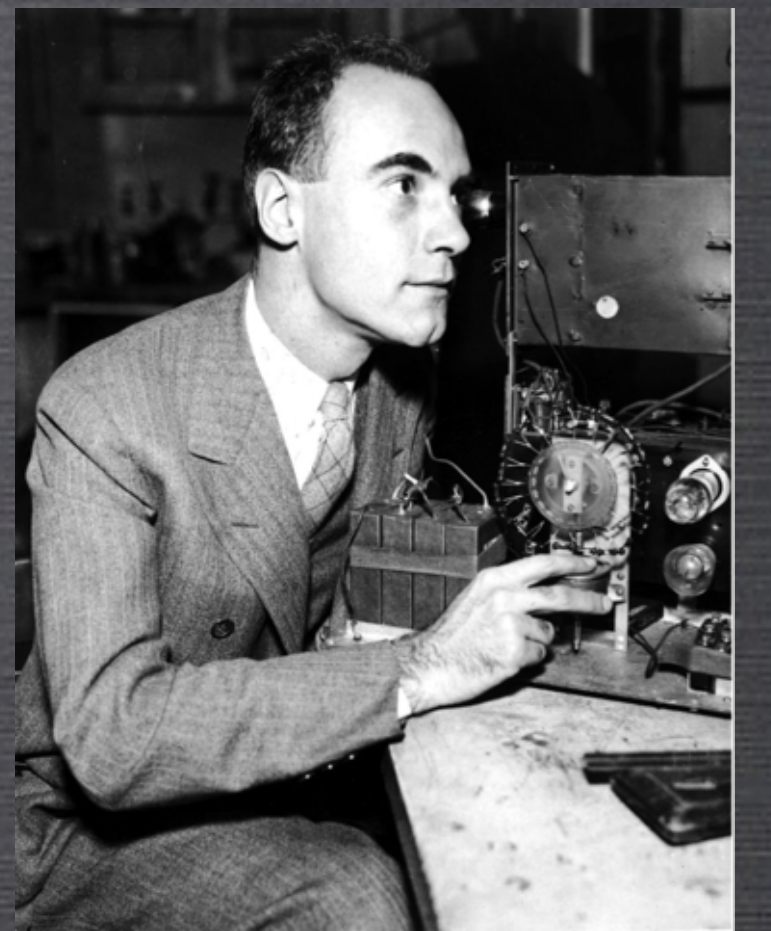
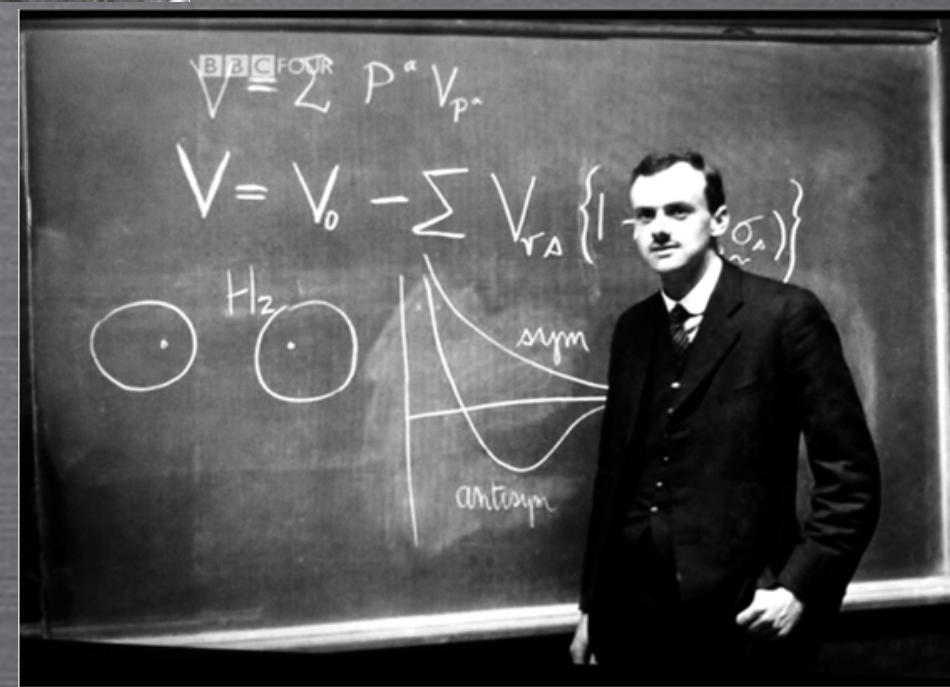
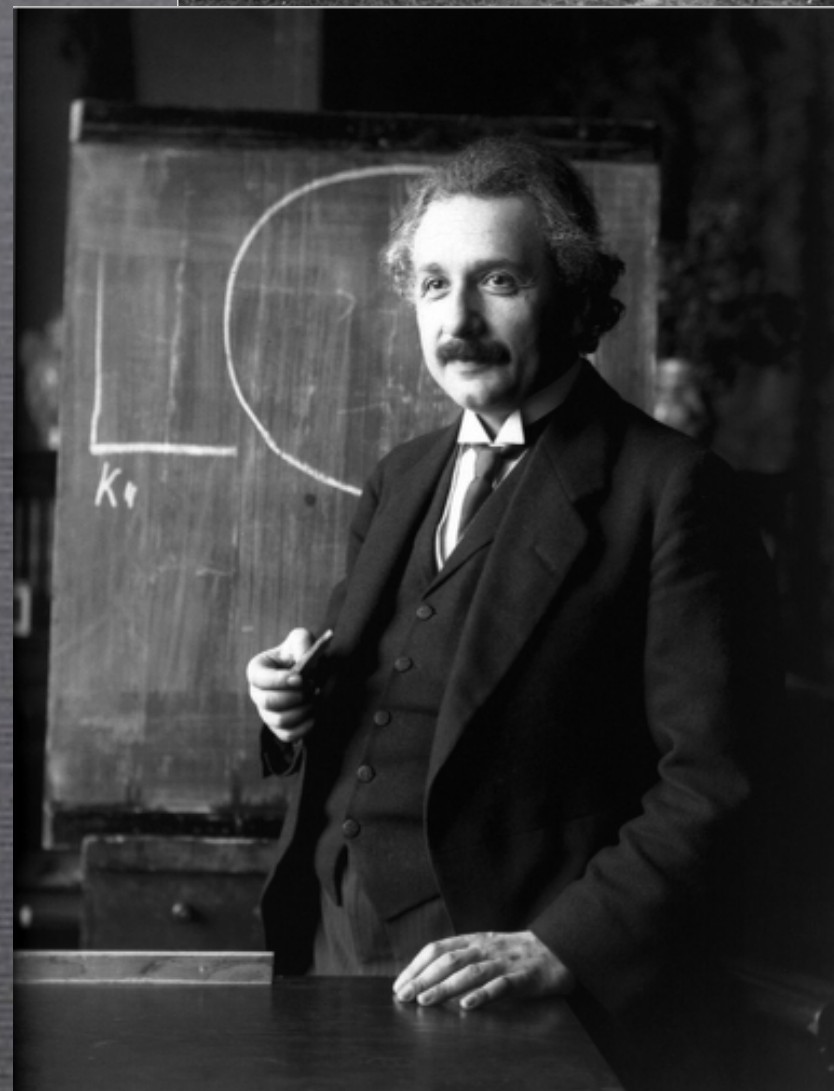
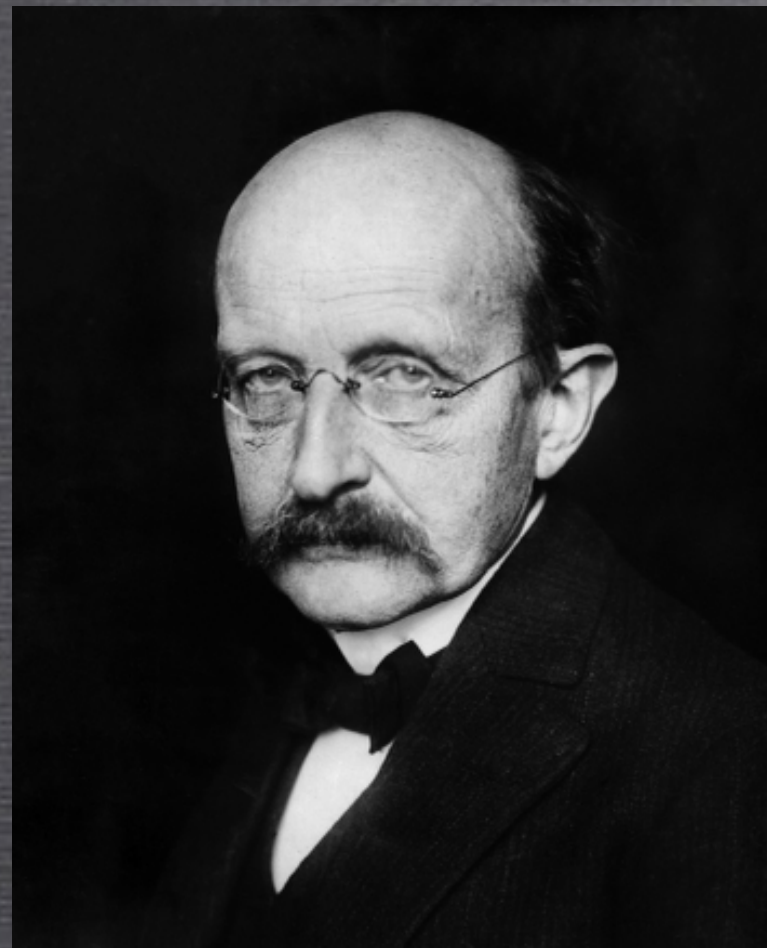
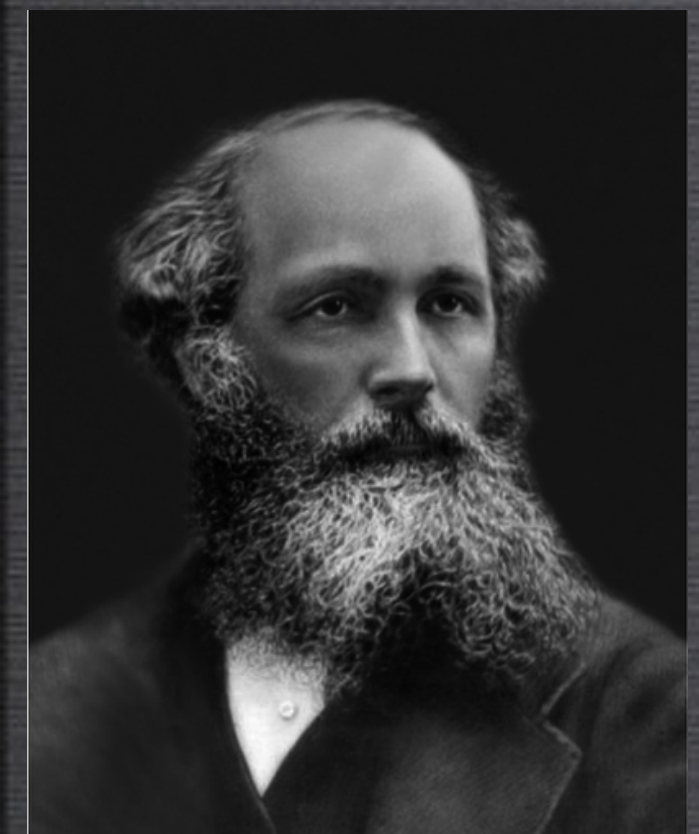
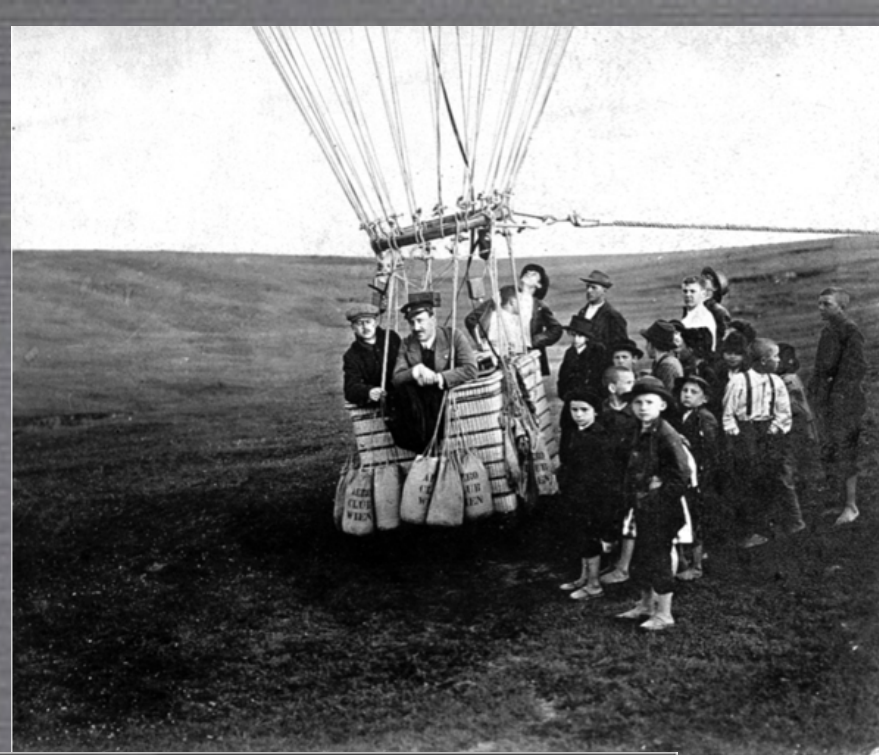
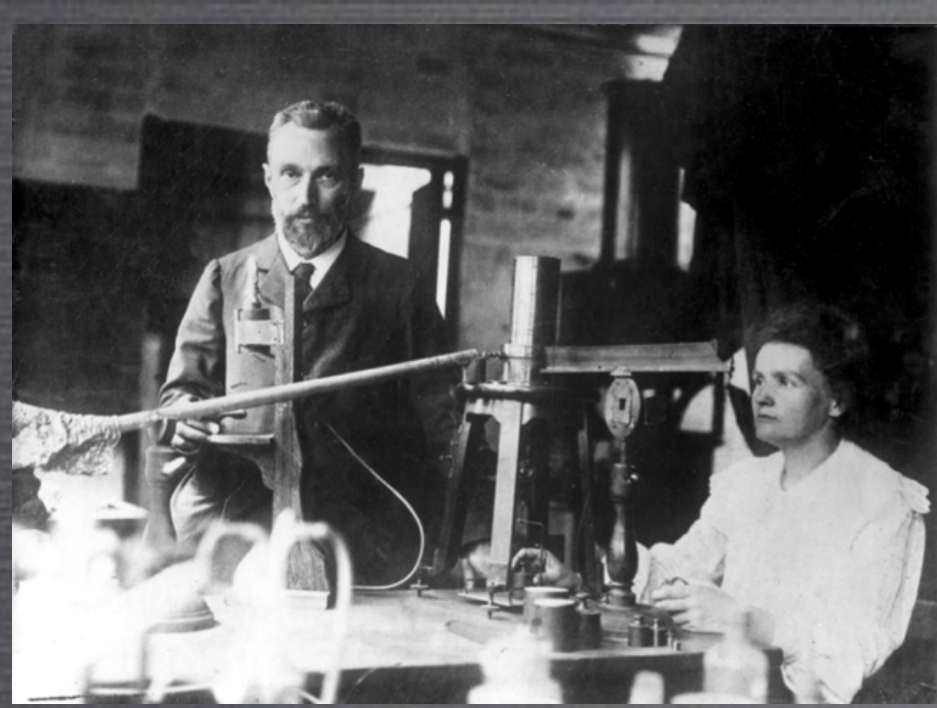
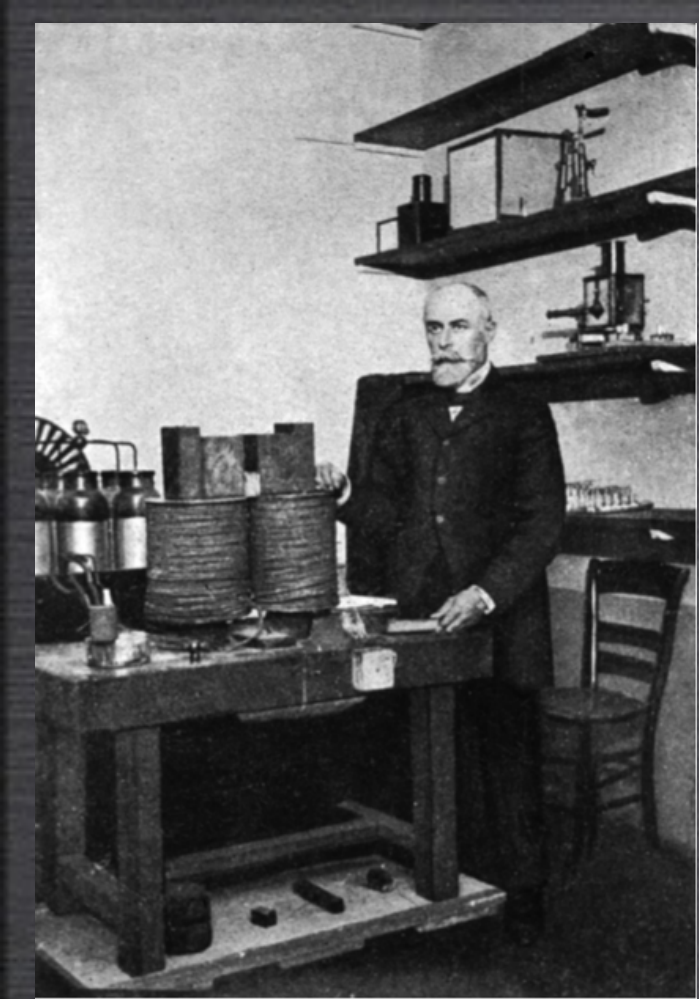
NOYAUX ACTIFS
DE GALAXIES
-
CENTAURUS A



LES NOUVELLES DONNÉES SONT MOINS CONVAINCANTES....
IL FAUT CONTINUER À CHERCHER

LES DONNÉES DE L'OBSERVATOIRE AUGER EN 2013 :

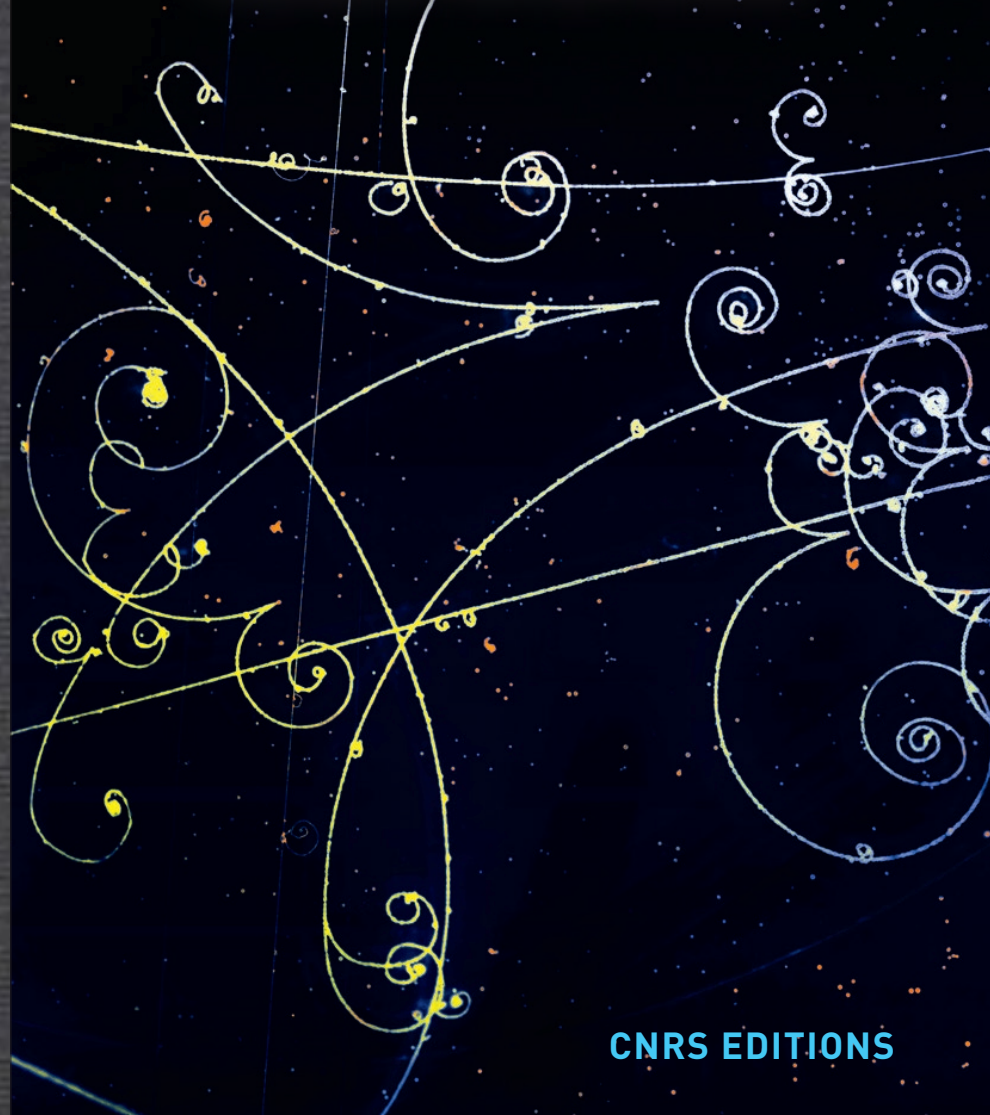




ANTOINE LETESSIER SELVON

Kosmos

L'épopée des particules



CNRS EDITIONS

